REPORT

OF THE

SEVENTH MEETING

OF THE

AUSTRALASIAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

HELD AT

SYDNEY, 1898

EDITED BY

A. LIVERSIDGE, M.A., LL.D., F.R.S.

Sydney:

PUBLISHED BY THE ASSOCIATION

PLEASE address all communications to—

THE PERMANENT HON. SECRETARY,
THE AUSTRALASIAN ASSOCIATION,
THE UNIVERSITY, GLEBE,
SYDNEY, NEW SOUTH WALES.

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Officers for the Sydney Session of the Association

JANUARY, 1898.

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PRESIDENT:

Professor A. LIVERSIDGE, M.A., LL.D., F.R.S.

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Professor W. H. BRAGG, M.A., The University, Adelaide.
JOHN SHIRLEY, B.Sc., District Inspector of Schools, Brisbane.

EX-OFFICIO MEMBERS OF THE COUNCIL:

The Council consists of the following:—(1) present and former Presidents, Vice-Presidents, Treasurers, and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections; (2) Authors of Reports or of Papers published *in extenso* in the Annual Reports of the Association.

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R. L. J. ELLERY, C.M.G., F.R.S., F.R.A.S.
Professor A. LIVERSIDGE, M.A., LL.D. F.R.S.

AUDITORS:

R. TEECE, F.I.A. R. A. DALLEN.

Publication Committee,

The President, the Hon. General Treasurer, and the Secretaries of the Sections.

Recommendation Committee:

The President, the Permanent Hon. Secretary, the past Presidents, and the past General Secretaries.

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By Rule 11 the Local Committee consists of the Members of Council resident in New South Wales, viz.:—

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Teece, R., F.I.A.
Thompson, J. Ashburton, M.D.
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Warren, Prof. W. H., M. Inst. C.E.
Wilson, Professor J. T., M.B.

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Barlow, J. B. (The Institute of Architects, N.S.W.)

Docker, His Hon. Judge E. B., M.A. (The Royal Society of N.S.W.)

Duckworth, A. (The Economic Association of N.S.W.)

Furber, T. F., F.R.A.S. (The Royal Society of N.S.W. and The Institution of Surveyors of N.S.W.)

Halligan, G. H., C.E. (The Institution of Surveyors of N.S.W.)

Hedley, Charles, F.L.S. (The Linnean Society of N.S.W.)

Norton, James, LL.D., M.L.C. (The Linnean Society of N.S.W.)

Quaife, F. H., M.A., M.D. (The Royal Society of N.S.W.)

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Baracchi, P., F.R.A.S. (The Royal Society of Victoria).

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Blackburn, The Rev. J.
Dixon, Samuel } (The Royal Society of South Australia).

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Morton, Alex., F.L.S. } (The Royal Society of Tasmania)

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS AT THE SYDNEY MEETING, 1898.

Sections.	Presidents.	Vice-Presidents.	Secretaries.
Section A.—Astronomy, Mathematics, and Physics.	P. Baracchi, F.R.A.S.	R. L. J. Ellery, C.M.G., F.R.S., F.R.A.S.; Prof. Alex. McAulay, M.A.; Prof. T. R. Lyle, M.A.	Prof. R. Threlfall, M.A.; J. Arthur Pollock, B.Sc.; G. H. Knibbs, F.R.A.S., L.S.
Section B.—Chemistry	....	Richard T. Bellemey, M.P.S.; Prof. E. H. Rennie, M.A., D.Sc.	W. M. Hamlet, F.I.C., F.C.S.
Section C.—Geology and Mineralogy...........	Prof. F. W. Hutton, F.R.S., F.G.S.	W. Howchin, F.G.S.; R. L. Jack, F.G.S.	Prof. T. W. E. David, B.A., F.G.S.; E. F. Pittman, A.R.S.M.
Section D.—Biology	Acting-Prof. C. J. Martin, M.B., D.Sc.	J. J. Fletcher, M.A., B.Sc.	Prof. W. A. Haswell, M.A., D.Sc., F.R.S.; J. H. Maiden, F.L.S.; J. J. Fletcher, M.A., B.Sc.
Section E.—Geography	Sir James Hector, K.C.M.G., F.R.S., M.D.	Hon. P. G. King, M.L.C., F.R.G.S.; A. C. Macdonald, F.R.G.S.	H. S. W. Crummer; John Mann.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS—*continued.*

Sections.	Presidents.	Vice-Presidents.	Secretaries.
Section F.—Ethnology and Anthropology ...	A. W. Howitt, F.G.S.	Prof. W. Baldwin Spencer, M.A.; Rev. L. Fison, M.A., LL.D.	John Fraser, B.A., LL.D.
Section G.—Economic Science and Agriculture.	R. M. Johnston, F.L.S., F.S.S.	Hon. H. N. MacLaurin, M.D., LL.D., M.L.C.; R. Teece, F.I.A., F.F.A.; W. McMillan, M.P.; E. M. Shelton, M.Sc.; W. Farrer, M.A.	R. R. Garran, B.A.; F. B. Guthrie, F.C.S.
Section H.—Engineering and Architecture ...	A. B. Moncrieff, M. Inst. C.E., M. AM. Soc. C.E.	H. Deane, M.A., M. Inst. C.E.; G. A. Mansfield; Prof. W. H. Warren, M. Inst. C.E., Wh.Sc.	J. W. Grimshaw, M. Inst. C.E., M.I. Mech. E.; H. C. Kent, M.A.
Section I.—Sanitary Science and Hygiene ...	The Hon. Allan Campbell, M.L.C., L.R.C.P.	D. Hardie, M.B.; J. W. Springthorpe, M.A., M.D.; J. Ashburton Thompson, M.D.	Frank Tidswell, M.B., Ch.M., D.P.H.
Section J.—Mental Science and Education ...	John Shirley, B.Sc.	Hon. A. Garran, M.A., LL.D.; R. H. Roe, M.A.	Prof. Francis Anderson, M.A.; J. B. Peden, B.A.; T. R. Bavin, B.A., LL.B.

Objects and Rules of the Association.

[Carried at the Christchurch Session in January, 1891; submitted and confirmed at the Hobart Session, January, 1892; *amended at the Sydney Session, January*, 1898.] The 1898 amendments are in *italics.*

OBJECTS OF THE ASSOCIATION.

The objects of the Association are to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the Australasian Colonies and in other countries; to obtain more general attention to the objects of science, and a removal of any disadvantages of a public kind which may impede its progress.

RULES OF THE ASSOCIATION.

Members and Associates.

1. Members shall be elected by the Council. The annual subscription shall be £1; but after 30th June, 1895, members will be required to pay an entrance fee of £1 in addition.

[*Amended as follows:—Members shall be elected by the Council.*]

2. The annual subscription shall be £1, due on the 1st July in each year.

[*Amended as follows:—The subscription shall be* £1 *for each Session, to be paid in advance.*]

3. A member may at any time become a Life Member by one payment of £10, in lieu of future annual subscriptions.

[*Amended as follows:—A member may at any time become a Life Member by one payment of* £10, *in lieu of future subscriptions.*]

4. Members who fail to pay their subscriptions before the Annual Session of the Association cease to be members, but may rejoin by paying the entrance fee in addition to the annual subscription.

5. The Local Committee may admit any person as an Associate for the year on the payment of £1.

6. Associates are eligible to serve on the Local Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

[*Rules* 4, 5, *and* 6 *are rescinded.*]

7. Ladies' tickets (admitting the holders to the General and Sectional Meetings, as well as the Evening Entertainments) may be obtained by full members on payment of 5s. for each ticket. Ladies may also become either Members or Associates on the same terms as gentlemen.

[*Amended as follows:—Ladies tickets (admitting the holders to the General and Sectional Meetings as well as the Evening Entertainments) may be obtained by full members on payment of* 10*s. for each ticket. Ladies may also become members on the same terms as gentlemen.*]

SESSIONS.

8. The Association shall meet in Session periodically for one week or longer. The place of meeting shall be appointed by the Council two years in advance, and the arrangements for it shall be entrusted to the Local Committee.

COUNCIL.

9. There shall be a Council consisting of the following :—(1) Present and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections. (2) Authors of Reports or of Papers published *in extenso* in the Annual Reports of the Association.

[*Amended as follows :—There shall be a Council consisting of the following :—*(1) *Present and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections.* (2) *Members of the Association delegated to the Council by Scientific Societies.*]

10. The Council shall meet only during the Session of the Association, and during that period shall be called together at least twice.

LOCAL COMMITTEES.

11. In the intervals between the Sessions of the Association its affairs shall be managed in the various Colonies by Local Committees. The Local Committee of each Colony shall consist of the Members of Council resident in that Colony.

OFFICERS.

12. The President, five Vice-Presidents (elected from amongst former Presidents), a General Treasurer, one or more General Secretaries and Local Secretaries shall be appointed for each Session by the Council.

13. The Governor of the Colony in which the Session is held shall be *ex-officio* a Vice-President. [*This Rule is rescinded.*]

RECEPTION COMMITTEE.

14. The Local Committee of the Colony in which the Session is to be held shall appoint a Reception Committee to assist in making arrangements for the reception and entertainment of the visitors. This Committee shall have power to add to its number.

OFFICE.

15. The permanent Office of the Association shall be in Sydney.

MONEY AFFAIRS OF THE ASSOCIATION.

16. The financial year shall end on the 30th June.

17. All sums received for life subscriptions and for entrance fees shall be invested in the names of three Trustees appointed by the Council, and the interest only, arising from such investment, shall be applied to the uses of the Association.

18. The subscriptions shall be collected by the Local Secretary in each Colony, and shall be forwarded by him to the General Treasurer.

19. The Local Committees shall not have power to expend money without the authority of the Council, with the exception of the Local Committee of the Colony in which the next ensuing Session is to be held, which shall have power to expend money collected or otherwise obtained in that Colony. Such disbursements shall be audited, and the Balance-sheet and the surplus funds forwarded to the General Treasurer.

20. All cheques shall be signed either by the General Treasurer and the General Secretary or by the Local Treasurer and the Secretary of the Colony in which the ensuing Session is to be held.

21. Whenever the balance in the hands of the Banker shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

22. The whole of the accounts of the Association—*i.e.*, the local as well as the general accounts—shall be audited annually by two Auditors appointed by the Council; and the Balance-sheet shall be submitted to the Council at its first meeting thereafter.

Money Grants.

23. Committees and individuals to whom grants of money have been entrusted are required to present to the following meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

24. In each Committee the Secretary is the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

25. In grants of money to Committees, or to individuals, the Association does not contemplate the payment of personal expenses to the members or to the individual.

Sections of the Association.

26. The following Sections shall be constituted :—

A.—Astronomy, Mathematics, and Physics.
B.—Chemistry.
C.—Geology and Mineralogy.
D.—Biology.
E.—Geography.
F.—Ethnology and Anthropology.
G.—Economic Science and Agriculture.
H.—Engineering and Architecture.
I.—Sanitary Science and Hygiene.
J.—Mental Science and Education.

Sectional Committees.

27. The President of each Section shall take the chair and proceed with the business of the Section at 11 a.m. precisely. In the middle of the day an adjournment for luncheon shall be made; and at 4 p.m. the Sections shall close.

28. [*Formerly No.* 33.] On the second and following days the Sectional Committees shall meet at 10 a.m.

29. The Presidents, Vice-Presidents, and Secretaries of the several Sections shall be nominated by the Local Committee of the Colony in which the next ensuing Session of the Association is to be held, and shall have power to act until their election is confirmed by the Council. The Sectional Presidents of former years shall be *ex officio* Members of the Organising Committees. From the time of their nomination, which shall take place as soon as possible after the Session of the Association, they shall be regarded as an Organising Committee, for the purpose of obtaining information upon papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

30. The Sectional Committees shall have power to add to their number.

Reading and Publication of Papers.

31. The Committees for the several Sections shall determine the acceptance of papers before the beginning of the Session. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an abstract of his paper, of a length suitable for insertion in the published Transactions,

Reports, or Proceedings of the Association, and that he should send it, together with the original paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the Session.

32. Members may communicate to the Sections the papers of non-members.

33. The author of any paper is at liberty to reserve his right of property therein.

34. No report, paper, or abstract shall be inserted in the annual volume unless it be handed to the Secretary before the conclusion of the Session.

35. The Sectional Committees shall report to the Publication Committee what papers it is thought advisable to print.

36. They shall also take into consideration any suggestions which may be offered for the advancement of science.

Research Committees.

37. In recommending the appointment of Research Committees, all members of such Committees shall be named, and one of them who has notified his willingness to accept the office shall be appointed to act as Secretary. The number of members appointed to serve on a Research Committee should be as small as is consistent with its efficient working. Individuals may be recommended to make reports.

38. All recommendations adopted by Sectional Committees shall be forwarded without delay to the Recommendation Committee; unless this is done the recommendation cannot be considered by the Council.

Official Journal.

39. At the close of each meeting the Sectional Secretaries shall correct, on a copy of the official journal, the lists of papers which have been read, and add to them those appointed to be read on the next day, and send the same to the General Secretaries for printing.

Recommendation Committee.

40. The Council at its first meeting at each Session shall appoint a Committee of Recommendations to receive and consider the reports of the Research Committees appointed at the last Session, and the recommendations from Sectional Committees. The Recommendation Committee shall also report to the Council, at a subsequent meeting, the measures which they would advise to be adopted for the advancement of science.

41. All proposals for the appointment of Research Committees and for grants of money (*see Rules* 23 *to* 25) must be sent in through the Recommendation Committee.

Publication Committee.

42. The Council shall each Session elect a Publication Committee, which shall receive the recommendation of the Sectional Committees with regard to publication of papers, and decide finally upon the matter to be printed in the volume of Transactions, Reports, or Proceedings.

Alteration of Rules.

43. No alteration of the Rules shall be made unless due notice of all such additions or alterations shall have been given at one Annual Meeting and carried at a subsequent Annual Meeting of the Council.

[*Amended as follows:—No alteration of the Rules shall be made unless due notice of all such additions or alterations shall have been given at one meeting and carried at another meeting of the Council, held during a subsequent Session of the Association.*]

INDEX TO RULES.

Presidents, Vice-Presidents, Secretaries, and Treasurers, from the Commencement.

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurer.
SYDNEY, 1888.			
H. C. Russell, B.A., F.R.S., F.R.A.S. (Sydney).	The Hon. Dr. J. W. Agnew (Tasmania). The Hon. Sir Frederick Darley, Knt. (N.S.W.) C. W. De Vis, M.A. (Queensland). The Mayor of Sydney, Alderman John Harris. Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). The Hon. James Inglis, M.P. (N.S.W.) Professor W. C. Kernot, M.A., C.E. (Victoria). The Hon. Sir W. M. Manning, LL.D., M.L.C. (Sydney). The Hon. H. N. MacLaurin, M.A., M.D., LL.D. (Sydney) Professor E. H. Rennie, M.A., D.Sc. (South Australia). Sir Alfred Roberts, M.R.C.S. (N.S.W.)	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.) George Bennett, M.D., F.L.S., F.Z.S. (N.S.W.)	Sir Ed. Strickland, K.C.B., F.R.G.S. (N.S.W.)

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
MELBOURNE, 1890.			
Baron Von Mueller, K.C.M.G., F.R.S., M. & Ph.D. (Victoria)	His Excellency Sir Robert G. C. Hamilton, K.C.B. (Tasmania). Professor Liversidge, M.A., LL.D., F.R.S. (N.S.W.) Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand) E. C. Stirling, M.A., M.D. (South Australia). W. Saville-Kent, F.L.S., F.Z.S. (Queensland). Professor Kernot, M.A., C.E. (Victoria).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.) Professor W. Baldwin Spencer, M.A. (Victoria).	H. C. Russell, B.A., F.R.S., F.R.A.S. (N.S.W.) R. L. J. Ellery, C.M.G., F.R.S., F.R.A.S. (Victoria)
CHRISTCHURCH, 1891.			
Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand)	His Excellency Sir R. G. C. Hamilton, K.C.B. (Tasmania). A. Leibius, M.A., Ph.D., F.C.S. (N.S.W.) Professor W. C. Kernot, M.A., C.E. (Victoria). W. Saville-Kent, F.L.S., F.Z.S. (Queensland). E. C. Sterling, M.D., M.A. (South Australia).	A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.) F. W. Hutton, F.G.S. (New Zealand).	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.) H. R. Webb, F.R.M.S. (Christchurch, N.Z.)

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
	HOBART, 1892.		
His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D. (Tasmania).	Professor W. C. Kernot (Victoria). Hon. A. Norton, M.L.C. (Queensland). Rev. Thomas Blackburn (South Australia). H. C. Russell, C.M.G., F.R.S. (N.S.W.)	Professor A. Liversidge, F.R.S., M.A., Permanent Hon. Sec. (N.S.W.) A. Morton, F.L.S. (Tas.)	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.) J. B. Walker, F.R.G.S. (Tas.)
	ADELAIDE, 1893.		
Professor Ralph Tate, F.G.S., F.L.S. (South Australia).	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.) Baron F. Von. Muller, K.C.M.G., Ph.D., F.R.S. (Victoria). Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand. Sir Robert Hamilton, K.C.B. (Tasmania). The Right Hon. the Earl of Kintore, P.C., G.C.M.G. (South Australia).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.) Prof. Rennie, M.A., D.Sc. (South Australia.) Professor Bragg, M.A. (South Australia).	H. C. Russell, F.R.S., B.A. (N.S.W.) Fredk. Wright (South Australia).

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
BRISBANE, 1895.			
The Hon. A. C. Gregory, C.M.G., M.L.C. (Queensland).	His Excellency Sir Henry Wylie Noman, G.C.B., G.C.M.G., C.B. (Queensland). H. C. Russell, C.M.G., B.A., F.R.S. (N.S.W.) Baron F. Von. Muller, K.C.M.G., Ph.D., F.R.S. (Victoria). Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand) Professor Ralph Tate, F.G.S., F.L.S. (South Australia).	Professor A. Liversidge, M.A., LL.D., F.R.S., Permanent Hon. Sec. (N.S.W.) John Shirley, B.Sc. (Queensland). C. W. De Vis, M.A. (Queensland).	H. C. Russell, C.M.G., F.R.S., F.R.A.S., B.A. (N.S.W.) Hon. A. Norton, M.L.C. (Queensland).
SYDNEY, 1898.			
Professor A. Liversidge, M.A., LL.D., F R.S., &c. (N.S.W.)	H, C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.) Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand) Professor Ralph Tate, F.G.S., F.L.S. (South Australia). The Hon. A. C. Gregory, C.M.G., M.L.C. (Queensland).	Professor A. Liversidge, M.A., LL.D., F.R.S., Permanent Hon. Secretary (N.S.W.)	H. C. Russell, C.M.G., F.R.S., F.R.A.S. (N.S.W.)

Presidents, Vice-Presidents, and Secretaries of the Sections of the Association.

SECTION A.—ASTRONOMY, MATHEMATICS, AND PHYSICS.

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
1888—Sydney, N.S.W....	R. L. J. Ellery, F.R.S., Melbourne.	....	Professor R. Threlfall, M.A.
1890—Melbourne, Vic. ...	Professor R. Threlfall, M.A., Sydney.	Professor T. R. Lyle, M.A.	E. F. J. Love, M.A. W. Sutherland, M.A.
1891—Christchurch, N.Z.	Professor T. R. Lyle, M.A., Melbourne.	C. H. H. Cook, M.A.	A. C. Gifford, M.A.
1892—Hobart, Tasmania.	Professor W. H. Bragg, M.A., Adelaide.	The Archbishop of Hobart. A. B. Biggs.	Captain Shortt, R.N. W. E. Shoobridge.
1893—Adelaide, S.A.......	H. C. Russell, B.A., F.R.S., C.M.G., Sydney.	Sir Charles Todd, K.C.M.G., M.A., F.R.S., F.R.A.S. J. J. Stuckey, M.A.	R. W. Chapman, M.A.
1895—Brisbane, Q'nsland.	Alexander McAulay, M.A., Tasmania.	Clement Wragge, F.R.M.S. C. H. Hodges, M.A. J. E. Davidson.	J. P. Thomson, F.R.S.G.S.
1898—Sydney, N.S.W....	P. Baracchi, F.R.A.S., Melbourne.	R. L. J. Ellery, C.M.G., F.R.S., Professor Alex. McAulay, M.A. Professor T. R. Lyle, M.A.	Professor R. Threlfall, M.A. J. Arthur Pollock, B.Sc. G. H. Knibbs, F.R.A.S., L.S.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	SECTION B.—CHEMISTRY.		
1888—Sydney, N.S.W....	Professor J. G. Black, D.Sc., M.A., Dunedin.	A. Leibius, Ph.D., M.A., &c. Prof. A. Liversidge, M.A., F.R.S. Professor E. H. Rennie, M.A.	W. M. Hamlet, F.I.C., F.C.S.
1890—Melbourne, Vic. ...	Professor E. H. Rennie, M.A., D.Sc., Adelaide.	C. R. Blackett, F.C.S.	Prof. Orme Masson, M.A., D.Sc.
1891—Christchurch, N.Z.	Professor Orme Masson, M.A., D.Sc., Melbourne.	Prof. A. W. Bickerton, F.C.S. W. S. Key, F.C.S.	George Gray, F.C.S.
1892—Hobart, Tasmania.	W. M. Hamlet, F.I.C., F.C.S., Sydney.	W. F. Ward, A.R.S.M. Samuel Clemes.	A. J. Taylor, F.L.S. H. T. Gould.
1893—Adelaide, S.A.......	C. N. Hake, F.C.S., F.I.C., Melbourne.	T. C. Cloud, F.C.S. G. Goyder, junr., F.C.S. A. Sutherland, M.A.	T. J. Greenway, F.C.S., F.I.C.
1895—Brisbane, Q'nsland.	J. H. Maiden, F.L.S., Sydney..	J. B. Henderson. George Henry Irvine. A. S. Denham.	George Watkins.
1898—Sydney, N.S.W....	....	Prof. E. H. Rennie, M.A., D.Sc. Richd. T. Bellemey, M.P.S.	W. M. Hamlet, F.I.C., F.C.S.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION C.—GEOLOGY AND MINERALOGY.			
1888—Sydney, N.S.W....	Robert L. Jack, F.R.G.S., F.G.S., Brisbane.	T. W. Edgeworth David, B.A., F.G.S.	Robert Etheridge, junr.
1890—Melbourne, Vic. ...	Professor F. W. Hutton, M.A., F.G.S., C.M.Z.S., Christchurch.	Professor McCoy, C.M.G., M.A., D.Sc.	James Stirling.
1891—Christchurch, N.Z.	R. A. Murray, F.G.S., Melbourne.	Professor A. P. Thomas, M.A., F.L.S., F.G.S. H. Hill, B.A., F.G.S.	J. D. Enys, F.G.S.
1892—Hobart, Tasmania.	Professor T. W. E. David, B.A., F.G.S., Sydney.	T. Stephens, M.A., F.G.S. A. Montgomery, M.A.	F. Belstead. B. Shaw.
1893—Adelaide, S.A.......	Sir. James Hector, K.C.M.G., M.D., F.R.S., Wellington.	Sir Henry Ayers, K.C.M.G., F.G.S. H. Y. L. Burnne, F.G.S. J. V. Parkes.	W. Howchin, F.G.S.
1895—Brisbane, Q'nsland.	Professor T. W. E. David, B.A., F.G.S., Sydney.	W. H. Rands. William Fryar. Ernest Lidgey.	W. A. Hargreaves, M.A., B.C.E.
1898—Sydney, N.S.W....	Professor F. W. Hutton, F.R.S., F.G.S., New Zealand.	W. Howchin, F.G.S. R. L. Jack, F.G.S.	T. W. E. David, B.A., F.G.S. E. F. Pittman, A.R.S.M.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION D.—BIOLOGY.			
1888—Sydney, N.S.W. ...	Professor Ralph Tate, F.L.S., F.G.S., Adelaide.	....	Prof. W. A. Haswell, M.A., D.Sc.
1890—Melbourne, Vic. ...	Professor A. P. Thomas, M.A., F.L.S., Auckland.	P. H. MacGillivray, M.A., M.R.C.S. J. Bracebridge Wilson, M.A., F.L.S.	A. Dendy, M.S.C., F.L.S.
1891—Christchurch, N.Z.	Professor W. A. Haswell, M.A., D.Sc., Sydney.	Professor T. J. Parker, B.Sc., F.R.S. Sir W. Buller, K.C.M.G., F.R.S. Thomas Kirk, F.L.S. T. F. Cheeseman, F.L.S.	C. Chilton, M.A., B.Sc. G. M. Thomson, F.L.S.
1892—Hobart, Tasmania.	Professor W. Baldwin Spencer, M.A., Melbourne.	Colonel Legge, R.A. W. F. Petterd, C.M.I.S. Augustus Simson.	P. S. Seager. L. Rodway, L.D.S.
1893—Adelaide, S.A.......	C. W. DeVis, M.A., Brisbane.	Revd. T. Blackburn, M.A. M. Holtze, F.L.S. E. C. Stirling, C.M.G., M.D., F.R.S.	W. L. Cleland, M.B.
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1898—Sydney, N.S.W....	Professor C. J. Martin, M.B., D.Sc., Melbourne.	Professor J. T. Wilson, M.B., Ch.M. J. J. Fletcher, M.A., B.Sc.	Professor W. A. Haswell, M.A., D.Sc., F.R.S. J. H. Maiden, F.L.S. J. J. Fletcher, M.A., B.Sc.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
		SECTION E.—GEOGRAPHY.	
1888—Sydney, N.S.W....	Hon. John Forrest, C.M.G., F.R.G.S., Perth, W.A.	G. S. Griffiths, F.R.G.S., F.G.S.	J. H. Maiden, F.R.G.S., F.L.S., F.C.S.
1890—Melbourne, Vic. ...	W. H. Miskin, F.E.S., Sydney.	Commander Crawford Pasco, R.N. A. C. Macdonald, F.R.G.S.	G. S. Griffiths, F.R.G.S., F.G.S.
1891—Christchurch, N.Z.	G. S. Griffiths, F.R.G.S., F.G.S., Melbourne.	S. Percy Smith, F.R.G.S. F. R. Chapman.	R. M. Laing, M.A., B.Sc.
1892—Hobart, Tasmania.	Commander Crawford Pasco, R.N., Melbourne.	E. A. Counsel, F.R.G.S. J. R. McClymont, M.A. Revd. J. B. Woollnough, M.A.	F. M. Young, B.A.
1893—Adelaide, S.A.......	A. C. Macdonald, F.R.G.S., Melbourne.	Sir S. Davenport, K.C.M.G. Sir T. Elder, G.C.M.G. David Murray. A. W. Goyder, C.M.G.	J. W. Jones.
1895—Brisbane, Q'nsland.	Baron F. v. Mueller, K.C.M.G., Ph.D., F.R.S., Melbourne.	J. N. Waugh, M.D. D. S. Thistlethwaite, C.E. Ernest Favenc.	Major A. J. Boyd.
1898—Sydney, N.S.W....	Sir James Hector, K,C.M.G., F.R.S., M.D., New Zealand.	Hon. P. G. King, M.L.C., F.R.G.S. A. C. Macdonald, F.R.G.S.	H. S. W. Crummer. John Mann.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION F.—ETHNOLOGY AND ANTHROPOLOGY.			
1888—Sydney, N.S.W....	A. Carroll, Sydney.	....	John Fraser, B.A., LL.D.
1890—Melbourne, Vic. ..	Hon. J. Forrest, C.M.G., M.L.C., Perth, W.A.	A. W. Howitt, F.G.S.	Revd. Lorimer Fison, M.A.
1891—Christchurch, N.Z.	A. W. Howitt, F.G.S., Melbourne.	Hon. W. B. D. Mantell, M.L.C., F.G.S. T. M. Hocken, M.R.C.S. Edward Tregear, F.R.G.S.	A. Hamilton.
1892—Hobart, Tasmania.	Revd. Lorimer Fison, M.A., Melbourne.	Revd. George Clark. James Barnard.	J. B. Walker, F.R.G.S.
1893—Adelaide, S.A.......	Revd. Samuel Ella, Sydney.	Revd. W. R. Fletcher, M.A. A. T. Magarey. T. A. Parkhouse. T. Worsnop.	T. Gill.
1895—Brisbane, Q'nsland.	Thomas Worsnop, Adelaide.	Thomas Petrie. Joseph Lauterer, M.D.	Archibald Meston.
1898—Sydney, N.S.W....	A. W. Howitt, F.G.S. Melbourne.	Prof. W. Baldwin Spencer, M.A. Rev. L. Fison, M.A., LL.D.	John Fraser, B.A., LL.D.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION G.—SOCIAL SCIENCE AND AGRICULTURE.			
1888—Sydney, N.S.W....	H. H. Hayter, C.M.G., Melbourne.	....	A. C. Wylie.
1890—Melbourne, Vic. ...	R. M. Johnston, F.L.S., Hobart.	Prof. J. S. Elkington, M.A., LL.B.	H. K. Rusden, F.R.G.S. A. Sutherland, M.A.
1891—Christchurch, N.Z.	Hon. G. W. Cotton, M.L.C., Adelaide.	W. T. L. Travers, F.L.S. W. R. E. Brown.	A. de Bathe Brandon, B.A. A. T. Bothamley.
1892—Hobart, Tasmania.	R. Teece, F.I.A., Sydney.	Hon. A. I. Clarke, M.E.C. Hon. N. J. Brown, M.H.A. A. J. Ogilvy.	R. M. Johnston, F.L.S.
1893—Adelaide, S.A.......	H. C. L. Anderson, M.A., Sydney.	Josiah Boothby, C.M.G. Professor Lowrie, B.Sc. L. H. Sholl. J. H. Symon, Q.C.	E. Pariss Nesbit.
1895—Brisbane, Q'nsland.	Professor Walter Scott, M.A. Sydney.	Sir John Madden, Kt., C.J., Victoria. Hon. A. J. Thynne, M.L.C. J. H. McConnel. Peter McLean. Alex. Paterson. John Cran.	Littleton E. Groom, M.A., LL.M. (Social Science.) William Soutter (Agriculture).
1898—Sydney, N.S.W....	R. M. Johnston, F.L.S., F.S.S., Hobart.	Hon. H. N. MacLaurin, M.D., M.L.C., LL.D. R. Teece, F.I.A., F.F.A. W. McMillan, M.L.A. E. M. Shelton, M.Sc. W. Farrer, M.A.	R. R. Garran, B.A. F. B. Guthrie, F.C.S.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION H.—ENGINEERING AND ARCHITECTURE.			
1888—Sydney, N.S.W....	Professor W. C. Kernot, M.A., C.E., Melbourne.	....	John Sulman, F.R.I.B.A. H. Deane, M.A., M.I.C.E.
1890—Melbourne, Vic. ...	Professor W. H. Warren, M.Inst.C.E., Sydney.	H. C. Mais, M. Inst. C.E. A. Purchas, C.E.	A. O. Sachse, C.E.
1891—Christchurch, N.Z.	John Sulman, F.R.I.B.A., Sydney.	R. Wilson, F.R.S.E., M.I.C.E. E. Dobson, M.I.C.E. C. Napier Bell, M.I.C.E. W. N. Blair, M.I.C.E.	R. J. Scott, A.M.I.C.E.
1892—Hobart, Tasmania.	C. Napier Bell, M.I.C.E., C.E., New Zealand.	C. H. Grant, C.E. James Fincham, C.E. F. Kayser. C. W. James, C.E., A.M.I.C.E.	W. W. Eldridge. A. North.
1893—Adelaide, S.A.......	R. J. Scott, A.M.I.C.E., New Zealand.	Hon. J. Martin, M.L.C. A. B. Moncrieff, M.Inst.C.E. J. H. Reed.	J. T. Arrow, A.M.I.C.E.
1895—Brisbane, Q'nsland.	James Fincham, M.Inst.C.E., Tasmania.	H. C. Stanley, M.Inst.C.E. A. B. Brady, A.M.Inst.C.E. Richard Gailey. G. Phillips, C.E., M.L.A.	Claude W. Chambers.
1898—Sydney, N.S.W....	A. B. Moncrieff, M.Inst.C.E., M.Am. Soc. C.E., Adelaide.	H. Deane, M.A., M.Inst.C.E. G. A. Mansfield. Professor W. H. Warren, M.Inst.C.E., Wh.Sc.	J. W. Grimshaw, M.Inst. C.E., M.I.Mech.E. H. C. Kent, M.A.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION I.—SANITARY SCIENCE AND HYGIENE.			
1888—Sydney, N.S.W....	J. Bancroft, M.D., Brisbane.	....	J. T. Wilson, M.B., C.M. F. B. Kyngdon.
1890—Melbourne, Vic. ...	J. Ashburton Thompson, M.D., D.P.H., Sydney.	A. P. Akehurst. G. Gordon, C.E.	G. A. Syme, M.B., F.R.C.S.
1891—Christchurch, N.Z.	Hon. Allan Campbell, M.D., M.L.C., Adelaide.	Professor J. H. Scott, M.D. I. de Zouche. C. Nedwill, M.D.	F. Ogston, M.D.
1892—Hobart, Tasmania.	Professor W. H. Warren, M.Inst.C.E., Sydney.	Hon. P. O. Fysh, M.L.C. C. E. Barnard, M.D. E. O. Giblin, M.D.	A. Mault.
1893—Adelaide, S.A.......	A. Mault, Hobart.	Hon. Allan Campbell, M.L.C. H. C. Whittell, M.D.	T. Borthwick, M.D.
1895—Brisbane, Q'nsland.	J. W. Springthorpe, M.A., M.D., M.R.C.S., Melbourne.	F. H. Vivian Voss, F.R.C.S. A. E. Salter, M.B. J. H. Little, M.B.	David Hardie, M.D.
1898—Sydney, N.S.W....	Hon. Allan Campbell, M.L.C., L.R.C.P., L.F.P.S., Adelaide	D. Hardie, M.B. J. W. Springthorpe, M.A., M.D. J. Ashburton Thompson, M.D.	Frank Tidswell, M.B., Ch.M., D.P.H.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
SECTION J.—MENTAL SCIENCE AND EDUCATION.			
1888—Sydney, N.S.W....	Professor E. V. Boulger, M.A., D.Lit., Adelaide.	....	E. L. Montefiore.
1890—Melbourne, Vic. ...	Hon. J. W. Agnew, M.D., M.L.C., Hobart.	Professor Tucker, M.A. J. Hamilton Clarke, Mus.Bac.	Louis Henry, M.D. Tennyson Smith.
1891—Christchurch, N.Z.	R. H. Roe, M.A., Brisbane.	Professor F. W. Haslam, M.A. G. F. Tendall, Mus.Bac.Oson.	A. Wilson, M.A. A. J. Merton.
1892—Hobart, Tasmania.	Professor E. E. Morris, M.A., Melbourne.	Hon. J. W. Agnew, M.D. Revd. Thomas Kelsh. Russell Young.	F. J. Young, B.A.
1893—Adelaide, S.A.......	Professor Henry Laurie, LL.D., Melbourne.	His Honor Chief-Justice Way, D.C.L. Prof. E.V. Boulger, M.A., D.Lit. H. P. Gill. J. A. Hartley, B.A., B.Sc.	J. A. Sunter, B.A.
1895—Brisbane, Q'nsland.	Professor Francis Anderson, M.A., Sydney.	Hon. T. J. Byrnes, B.A., LL.B. M.L.A. Reginald H. Roe, M.A. J. Brunton Stephens. Thomas Bradbury.	J. L. Woolcock, B.A. (Mental Science). J. J. Dempsey (Education).
1898—Sydney, N.S.W....	John Shirley, B.Sc., Brisbane.	Hon. A. Garran, M.A., LL.D. R. H. Roe, M.A.	Prof. Francis Anderson, M.A. J. B. Peden, B.A. J. R. Bavin, B.A., LL.B.

List of Evening Lectures.

Date and Place.	Lecturer.	Subject of Discourse.
Sydney ...... (1888)	Sir James Hector, K.C.M.G., M.D., F.R.S.	The Volcanic Eruptions of the Hot Lake District of New Zealand.
	Prof. W. Baldwin Spencer, M.A.	On his recent Discoveries on the Pineal Eye.
Christchurch (1891)	G. E. Mannering	The Glaciers of the Tasman Valley.
	W. Saville Kent, F.L.S., F.Z.S.	Oysters and Oyster Culture in Australia.
	G. F. Tendall, Mus. Bac. (Oxon.)	The History of Vocal Music.
Hobart ...... (1892)	C. W. Adams	The Great Sutherland Waterfalls.
	J. B. Walker	Early Hobart.
Adelaide...... (1893)	C. W. de Vis, M.A.	The Diprotodon and its Times.
	E. C. Sterling, C.M.G., M.D., F.R.S.	Prehistoric Man.
Brisbane...... (1895)	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S.	Star Depths.
	Dr. N. Cobb, Ph. D.	Looking Forward.
Sydney ...... (1898)	Prof. W. Baldwin Spencer, M.A.	The Centre of Australia.
	Sir James Hector, K.C.M.G., M.D., F.R.S.	Antarctica and the Islands of the Far South.
	J. A. Pollock, B. Sc.	Electric Signalling without Wires.

Balance Sheets, Sydney Session, 1898.

June 30, 1895, to June 30, 1898.

Victoria.

Dr. | *Cr.*

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1895	To Balance	6	11	7	30 June.	By General expenses	5	0	0
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						,, Prof. Rennie, postages	1	1	0
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						,, *Advertiser*, S.A.	2	9	0
						,, Postages, Hon. Treasurer	0	1	0
						,, Telegram to Sydney	0	2	0
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						,, Balance in Bank of Adelaide	5	9	10
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BALANCE SHEETS, SYDNEY SESSION, 1898—*continued*.

QUEENSLAND.

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		£ s. d.			£ s. d.
1898	To Subscriptions (Sydney Session)	51 0 0	1898	By Postages on circulars, &c.	2 1 8
				,, Clerical assistance	1 0 0
				,, Cheque to Sydney office	47 18 4
	£	51 0 0		£	51 0 0

NEW ZEALAND.

		£ s. d.			£ s. d.
1895	To Balance	0 15 9	1898	By Postages	3 19 5
1898	,, Subscriptions	38 8 6		,, Exchanges on cheques	0 6 6
				,, Stationery	2 5 10
				,, Cheque to Sydney office	22 6 0
				,, Balance retained in New Zealand	10 6 6
	Dr. Balance—£10 6s. 6d.				
	£	39 4 3		£	39 4 3

TASMANIA.

		£ s. d.			£ s. d.
1898	To Subscriptions collected and exchanges	6 1 0	1898	By Cheque to Sydney office	6 1 0

The Hon. Treasurer in Account with the Australasian Association for the Advancement of Science.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE, 30TH JUNE, 1895, TO 30TH JUNE, 1898. *Cr.*

1898.		£ s. d.	£ s. d.
30 June	Balance in Bank N.S. Wales, July 1, 1895.	139 13 1	
	,, Commercial Bank of Australia, 1 July, 1895	1 0 1	
			140 13 2
	To Members' subscriptions	491 0 0	
	Life members' subscriptions	30 0 0	
	Subscriptions from Adelaide	52 2 8	
	,, ,, Brisbane	47 18 4	
	,, ,, Melbourne	30 0 0	
	,, ,, New Zealand	22 6 0	
	,, ,, Tasmania	6 1 0	
			679 8 0
	From Brisbane Session (1895)	....	70 11 6
	Interest on mortgage	....	123 15 6
	From sales of Vols. of Proceedings	....	12 9 0
			£1,026 17 2

1898.		£ s. d.	£ s. d.
30 June	By clerical assistance (from June 30, 1895)	263 17 0	
	Printing and stationery	206 2 5	
	Advertising	80 18 10	
	Postages and exchanges	60 0 7	
	Petty expenses	56 1 11	
	Handbook	25 0 0	
	Hire of decorations and furniture	58 12 1	
			750 12 10
	General expenses at meeting	60 8 6	
	Liedertafel concert	35 0 0	
			95 8 6
	Investment Account	....	0 19 5
	Transfer of life members' subscriptions and sales of Vols. of Proceedings, to Investment Account	....	42 9 0
	Balance in Bank of N. S. Wales, June 30, 1898	134 13 4	
	Balance in hand	2 14 1	
			137 7 5
			£1,026 17 2

INVESTMENT ACCOUNT.

1898.		£ s. d.
30 June	To Balance	1,399 0 7
	,, Cash from Working Account	0 19 5
	Received Life members' subscriptions	30 0 0
	,, From sales of Vols. of Proceedings	12 9 0
		£1,442 9 0

1898.		£ s. d.
30 June	By Investment on Mortgage	1,400 0 0
	,, Balance in Bank N.S. Wales	42 9 0
		£1,442 9 0

Audited and found correct,— { RICHARD TEECE, ROBERT A. DALLEN.

H. C. RUSSELL, Hon. Treasurer.

Table showing Attendances and Receipts, and Sums Paid or Voted for Scientific Purposes.

Date of Meeting.	Place of Meeting.	President.	Secretary.	Attended by: Members.	Attended by: Ladies.	Total.	Amount received up to and during the Meeting.	Sums granted for Scientific Purposes.
							£ s. d.	£ s. d.
1888 Aug.–Sep.	Sydney, New South Wales.	H. C. Russell, C.M.G., B.A., F.R.S.	A. Liversidge, M.A., LL.D., F.R.S.	805	45[1]	850	858 8 0	......
1890—Jan....	Melbourne, Victoria.	Baron von Mueller, K.C.M.G., Ph.D., F.R.S.	W. Baldwin Spencer, M.A.	1,081	81[1]	1,162	2,081 0 0	......
1891—Jan....	Christchurch, New Zealand	Sir James Hector, K.C.M.G., M.D., F.R.S.	Captain F. W. Hutton, F.R.S., F.G.S., C.M.Z.S.	...	......	550	785 13 7	25 0 0
1892—Jan....	Hobart, Tasmania.	His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D.	A. Morton, F.L.S.	...	......	600	933 16 3	......
1893—Sept...	Adelaide, South Australia.	Ralph Tate, F.G.S., F.L.S.	E. H. Rennie, D.Sc. ... W. H. Bragg, M.A.	367	121[2]	488	*426 2 0	30 0 0
1895—Jan....	Brisbane, Queensland.	Hon. A. C. Gregory, C.M.G. F.R.G.S., M.L.C.	John Shirley, B.Sc. ... C. W. de Vis, M.A.	392 †10[2]	122[2]	524	‡858 7 2	10 0 0
1898—Jan....	Sydney, New South Wales.	A. Liversidge, M.A., LL.D., F.R.S., &c.	A. Liversidge, LL.D., F.R.S.	573 †8[3]	104[1]	685	815 12 6	25 0 0

* From South Australian sources only. † Students, youths under 21. ‡ From all sources in Queensland only.
[1] Paid 20s. subscription. [2] Paid 5s. subscription. [3] Paid 10s. subscription.

Extracts from the Minutes

OF THE

FIRST MEETING OF THE GENERAL COUNCIL OF THE AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SEVENTH SESSION, HELD IN THE GREAT HALL OF THE UNIVERSITY, SYDNEY, ON THURSDAY, JANUARY 6TH, 1898, AT 4 P.M.

MR. H. C. RUSSELL, Vice-President, was voted to the Chair. About sixty members were present.

It was proposed by Professor Ralph Tate (South Australia) and seconded by Mr. R. M. Johnston (Tasmania) that (1) the arrangements for the Session made by the Sydney Council, and (2) the nomination of Officers by it be approved of. The motion was carried unanimously.

On the motion of the Chairman, the 404 new candidates for membership who had paid their subscriptions for the Sydney Session were elected members.

The Hon. Treasurer stated that the balance-sheet for the Sydney Session, 1898, would be submitted later on.

A Recommendation Committee, consisting of the President, the permanent Hon. Secretary, the past Presidents, and past General Secretaries, was appointed, upon the motion of Professor McAulay (Tasmania), seconded by Sir James Hector (New Zealand).

Professor Liversidge gave notice of proposed alterations in Rules 1, 7, 9, and 13.

It was proposed by Mr. W. M. Hamlet (New South Wales), seconded by Professor T. W. E. David (New South Wales), that the following Committee be appointed to suggest means for the establishment of a memorial in honour of the late Baron von Mueller:—Professor Ralph Tate (South Australia), Professor W. Baldwin Spencer (Victoria), Mr. F. M. Bailey (Queensland), Professor A. Liversidge and Mr. J. H. Maiden (New South Wales), Mr. R. M. Johnston (Tasmania), Mr. A. Morton (Tasmania), and Captain F. W. Hutton (New Zealand).

Reports were presented from Research Committees appointed to inquire upon :—

(1) Seismological Phenomena in Australasia (Mr. Geo. Hogben).

(2) Our knowledge of the Thermodynamics of the Voltaic Cell (Mr. J. A. Pollock).

(3) On the Composition and Properties of the Mineral Waters of Australasia (Mr. Geo. Gray).

(4) On the occurrence of Glacial Boulders at Yellow Cliff, Crown Point Station, Finke Valley, Central Australia (Professor T. W. E. David).

(5) On the evidence of Glacial Action in the Port Victor and Inman Valley Districts, South Australia (Professor T. W. E. David).

(6) List of Vernacular Names of Australian Birds (Mr. A. J. Campbell).

It was proposed by Mr. A. Morton (Tasmania), and seconded by Mr. R. M. Johnston (Tasmania), that the next place of meeting, *i.e.*, the Ninth Session, in 1902, after the Melbourne Session in 1900, should be Hobart (Tasmania). This was postponed for consideration at the next meeting of the Council.

It was announced by Professor Liversidge that communications had been received from the Royal Society of London regarding the compilation of the Australasian portion of an International catalogue of scientific literature, and he moved that an Advisory Committee, with power to add to its number, be appointed, consisting of the following representatives from all the colonies :—Sir James Hector (New Zealand), Mr. J. Stirling (Victoria), Professor E. H. Rennie (South Australia), Professor W. Baldwin Spencer (Victoria), Mr. R. L. Jack (Queensland), Mr. T. S. Hall (Victoria), Mr. A. Morton (Tasmania), Professor Ralph Tate (South Australia), Mr. W. Howchin (South Australia), Mr. John Shirley (Queensland), and the mover. The motion was carried unanimously.

Second Meeting of the General Council, held in the Great Hall, at the University, on Monday, January 10th, 1898, at 4 p.m.

The President (Professor Liversidge) in the Chair. About thirty-five members were present.

The minutes of the previous meeting were read and confirmed.

Professor W. C. Kernot (Victoria) moved, and Mr. A. C. Macdonald (Victoria) seconded, that Mr. R. L. J. Ellery, C.M.G., F.R.S., be elected President, and Professor W. Baldwin Spencer and Mr. E. F. J. Love be elected Joint Hon. Secretaries for the ensuing Session of the Australasian Association for the Advancement of Science, to be held in Melbourne in 1900. Professor W. Baldwin Spencer (Victoria) moved, and Professor W. C. Kernot (Victoria) seconded, that Mr. C. R. Blackett be Hon. Treasurer. Both motions were carried unanimously.

On the motion of Sir James Hector, F.R.S. (New Zealand), seconded by Captain F. W. Hutton, F.R.S. (New Zealand), it was resolved that the place for the Session next following that of the Melbourne meeting be Hobart (Tasmania), in 1902.

It was resolved that the following gentlemen constitute the Publication Committee, viz. :—The President, the Hon. General Treasurer, and the Secretaries of the ten Sections. This was carried unanimously.

It was resolved that all the words in Rule 1 after "Council" be omitted, and that Rules 4, 5, 6 be omitted entirely, and that "ten shillings" be substituted for "five shillings" in Rule 7.

It was resolved that the second clause of Rule 9—*i.e.*, "Authors of reports or of papers published *in extenso* in the Annual Reports of the Association,"—be omitted, and that the words "and members of the Association delegated by Scientific Societies" be substituted. It was also agreed that Rule 13 be omitted, and that the permanent Hon. Secretary be authorised to make all necessary consequential alterations in the Rules.

Third Meeting of the General Council, held at the University, on Thursday, January 13th, 1898, at noon.

The President (Professor Liversidge) in the Chair. About fifty members were present.

The Report of the Recommendation Committee was presented and adopted. (For particulars see pages xlvi–xlviii.)

The Report of the Baron von Mueller Memorial Committee (see page xlix) was considered.

The Report of the International Catalogue of Scientific Literature Committee (see page xlix) was considered and adopted.

Messrs. R. Teece and R. A. Dallen were re-elected as honorary auditors.

Votes of Thanks

Were moved, and carried unanimously, to the following :—

(1.) To the Senate of the Sydney University, for the use of the University buildings during the Session.

(2.) To the Commissioners of the Queensland, New South Wales, Victorian, South Australian, and Tasmanian Railways, for concessions in railway fares granted to members; and to the Commissioners of the New South Wales Railways for a free train to members to visit the Blue Mountains.

(3.) To the Adelaide Steamship Co., the A.U.S. Navigation Co., the Union Steamship Co., Messrs. Howard Smith and Sons, and Messrs. Huddart, Parker, for concessions in steamer fares.

(4.) To Mr. John Howell, Managing Director of the Smelting Company of Australia, for an invitation to visit the works of the Company at Dapto; and to Mr. E. W. Knox, J.P., for an invitation to visit the Works of the Colonial Sugar Company at Pyrmont.

(5.) To the Royal Society of New South Wales, for a Conversazione ; the Sydney Liedertafel, for a Concert; Mrs. H. C. Russell, for a Garden Party ; and to Miss L. Macdonald, and the Victoria Ladies' Club, for "At Homes" to members.

(6.) To Sir James Hector, Professor W. Baldwin Spencer, and Mr. J. A. Pollock, for Lectures delivered during the Session.

(7.) To the Sydney Press, for assistance rendered by publishing reports of the proceedings of the Session.

(8.) To Mr. J. Witter Allworth, Acting Chief-Surveyor of the Department of Lands; to Mr. W. C. Piguenit, and to Mr. W. L. Vernon, Government Architect, for assistance rendered.

(9.) To Professor A. Liversidge, President and permanent Hon. Secretary, for the services he had rendered to the Association as President and General Secretary for the Sydney Session.

(10.) A special vote of thanks was passed on behalf of the visiting members from the other colonies and New South Wales country districts, to all those hosts and hostesses who had so kindly afforded private hospitality to visitors during the Sydney Session.

Resolved,—That Professor Liversidge, the President, be authorised to sign the Minutes of this final meeting of the General Council for the Sydney Session of 1898.

ADDRESS TO THE QUEEN.

Professor Liversidge stated that the following Address to the Queen was being prepared for presentation, on behalf of the Association :—

"Sydney, January, 1898.

"HER MOST GRACIOUS MAJESTY,

"VICTORIA, QUEEN OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND, AND ITS DEPENDENCIES: EMPRESS OF INDIA.

"May it please Your Majesty :

"WE, the President and Council of the Australasian Association for the Advancement of Science, on behalf of the Members resident in the Australian Colonies, in Tasmania, in New Zealand, and in Fiji (now assembled in Session in Sydney), approach Your Majesty to express our deep affection and loyalty, and to offer to Your Majesty our heartfelt congratulations on the completion of the 60th year of Your Majesty's beneficent and illustrious reign, during which so much has been done for the advancement of Science, and the well-being of Your Majesty's happy, united, and prosperous people.

"On behalf of and in the name of the Australasian Association for the Advancement of Science,—

"A. LIVERSIDGE,
"President."

To which the following reply has since been received :—

"Sir, "Government House, Sydney, 23rd June, 1898.

"I have the honour, by direction of His Excellency the Governor, to inform you that a Despatch has been received, from the Secretary of State for the Colonies, intimating that the Address from the Australasian Association for the Advancement of Science has been duly laid before Her Majesty.

"Her Majesty was pleased to command that Her warm thanks should be conveyed to the Members of your Association for the kind expressions of loyalty contained in the beautifully-illuminated address of congratulation.

"I have the honour to be, Sir,
"Your most obedient servant,
"H. G. FEILDEN,
"Private Secretary.

"The President,
"Australasian Association for the Advancement of Science,
"The University, Sydney."

Committees of Investigation.

No. 1.—Committee upon the Magnetic Survey of New Zealand.

On the recommendation of Section A (Astronomy, Mathematics, and Physics), it was agreed that,—in view of the recent investigation by Dr. Adolf Schmidt, in which it is shown that the undertaking of systematic magnetic observations in New Zealand, as the most suitable locality in respect of the significance of the phenomena, is a work of great scientific importance, an opinion also held previously by the Royal Society of London and by the prominent magneticians of the British Association, and endorsed by this Association,—this Association recommends that a magnetic survey of the Colony, together with observations at a permanent station as far south as possible, should be undertaken in New Zealand; and that a Committee, consisting of Mr. P. Baracchi, F.R.A.S., Mr. R. L. J. Ellery, C.M.G., F.R.S., Sir Jas. Hector, K.C.M.G., M.D., F.R.S., Mr. H. C. Russell, C.M.G., F.R.S., Sir Chas. Todd, K.C.M.G., F.R.A.S., and Mr. C. C. Farr, B.Sc. (Christchurch, New Zealand), Hon. Sec., be appointed to take such steps as are necessary to bring the matter to an issue.

No. 2.—Seismological Committee.

On the recommendation of Section A (Astronomy, Mathematics, and Physics), it was agreed that the following be the Seismological Committee to report to the Melbourne Meeting in 1900:—New South Wales—Mr. Mr. H. C. Russell, B.A., C.M.G., F.R.S., F.R.A.S.; Victoria—Mr. P. Baracchi, F.R.A.S.; Mr. R. L. J. Ellery, C.M.G., F.R.S., F.R.A.S.; S. Australia—Sir C. Todd, K.C.M.G., F.R.A.S.; Queensland—Mr. R. L. Jack, F.G.S., F.R.G.S.; New Zealand—Sir Jas. Hector, K.C.M.G., M.D., F.R.S.; Tasmania—Mr. A. B. Biggs; Prof. A. M'Aulay, M.A.; West Australia—Mr. W. E. Cooke, M.A.; and Mr. G. Hogben, M.A. (Timaru, New Zealand), Secretary.

No. 3.—Committee on the Mineral Waters of Australasia.

On the recommendation of Section B (Chemistry), it was agreed that the following be a Committee, with power to add to their number not more than one representative for each colony not already represented, to continue the investigation of the mineral waters of Australasia:—Professor Liversidge, M.A., LL.D., F.R.S.; Professor Rennie, M.A., D.Sc.; and Mr. G. Gray, F.C.S. (Christchurch, New Zealand), Secretary.

No. 4.—Committee on Photographic Geological Surveys.

On the recommendation of Section C (Geology and Mineralogy), it was agreed that the Committee appointed at the Session of 1892 to report on "The Systematic Conduct of the Photographic Work of Geological Surveys," which presented a progress report at the 1893 Session, but which had no opportunity to prepare a further report for presentation at Brisbane in January, 1895, be re-appointed. The following gentlemen are now appointed as members of this Committee:—Mr. P. Baracchi, F.R.A.S.; Professor T. W. E. David, B.A., F.G.S.; Mr. T. F. Furber, F.R.A.S., L.S.; Sir Jas. Hector, K.C.M.G., M.D., F.R.S.; Professor R. Tate, F.G.S., F.L.S.; and Mr. J. H. Harvey (East Melbourne, Victoria), Secretary.

No 5.—Committee on Australasian Biological Literature.

On the recommendation of Section D (Biology), it was agreed that the following Committee, with power to add to its number one additional member for each colony, be appointed to draw up a list of works and papers relating to the Australian flora, to constitute Part I of a general Australian Biological Bibliography:—Mr. F. M. Bailey, F.L.S.; Mr. J. G. Luehmann, F.L.S.; Mr. J. H. Maiden, F.L.S.; Mr. Rodway; Professor Tate, F.G.S., F.L.S.; and Mr. J. J. Fletcher, M.A., B.Sc. (Linnean Society of N.S.W., Sydney), Secretary.

Recommendations agreed to.

Seismological Station.

No. 1.—On the recommendation of Section A (Astronomy, Mathematics, and Physics), it was agreed that with a view to carrying out the work of observing seismological phenomena all over the world, so urgently recommended by the Seismological Committee of the British Association, the Australasian Association for the Advancement of Science strongly urge upon the New Zealand Government the desirability of equipping the station named in the list of the International Seismological Committee with one of the instruments approved by them and by the Seismological Committee of the British Association. The station in question is Timaru, where a qualified observer, Mr. George Hogben, resides, willing to take charge of the instrument and to duly report results of observations taken.

Magnetic Records.

No. 2.—On the recommendation of Section A (Astronomy, Mathematics, and Physics), it was agreed that in view of the importance attached to magnetic observations in the Southern Hemisphere, this Association regards the publication of the Victorian Continuous Records of magnetic elements as essential in the interests of magnetic science, and considers it very desirable that those records should be made available for the work undertaken by the Royal Society of London and the British Association.

Seismological Records.

No. 3.—On the recommendation of Section A (Astronomy, Mathematics, and Physics), it was agreed to set apart £25 to be used (if necessary and if the funds permit) towards the cost of setting up at Timaru, under the charge of Mr. George Hogben, one of the horizontal pendulums recommended by the Seismological Committee of the British Association and the International Seismological Committee. (Note.—The last vote, £10, granted to Mr. Hogben at the meeting of the Australasian Association for the Advancement of Science, in 1895, has not been used.)

Borings at Funafuti.

No. 4.—On the recommendation of Section C (Geology and Mineralogy), it was agreed that the Council of this Association bring under the notice of the Government of New South Wales the importance of completing the borings at Funafuti Atoll while the drilling apparatus remains on the island, and while the old bore is in sufficiently good order to be utilised, as is now the case.

Prismatic Sandstone Quarry, Bondi.

No. 5.—On the recommendation of Section C (Geology and Mineralogy), it was strongly recommended that the Government of New South Wales be asked to acquire the quarry of prismatic sandstone at Bondi, with the object of preserving it from destruction, as it is the best known example of a remarkable geological occurrence.

Spelling of Native Names.

[The following recommendation on the spelling of Native Names was forwarded by the Committee of Section F (Ethnology and Anthropology), but it was received too late for consideration by the General Council :—
"We recommend to the General Council that communication be entered into with the Governments of the respective colonies directing their attention to the desirability of the adoption by them of an uniform system of spelling native words, either names of places or other names, in accordance with the system adopted by the Royal Geographical Society of England and the Admiralty."]

Report of the Baron von Mueller Memorial Committee,

Held at the Sydney University, on Wednesday, January 12th, 1898, consisting of Mr. J. H. Maiden (N. S. Wales), Professor W. Baldwin Spencer (Victoria), Professor Ralph Tate (South Australia), Mr. F. M. Bailey (Queensland), Captain F. W. Hutton (New Zealand), Messrs. R. M. Johnston and A. Morton (Tasmania). Professor Liversidge presided. The following resolutions were passed :—

(1.) That this Association places upon record its sense of the deep loss sustained by the death of the late Baron von Mueller, and its high appreciation both of his personal character and of the distinguished services rendered by him to science.

(2.) That Professor Liversidge and Mr. J. H. Maiden be appointed to officially represent the Association upon the Baron von Mueller National Fund Committee.

Report of the Committee appointed of Representatives from all the Colonies to assist in the Compilation of the Australasian portion of an International Catalogue of Scientific Literature, consisting of:—

Professor Liversidge (N. S. Wales), Professor W. Baldwin Spencer, Messrs. T. S. Hall and J. Stirling (Victoria), Professors E. H. Rennie, Ralph Tate, and Mr. W. Howchin (South Australia), Messrs. R. L. Jack and J. Shirley (Queensland), Sir James Hector (New Zealand), Mr. Alex. Morton (Tasmania).

The Committee met on Wednesday, January 12th, 1898, at the University. Professor Liversidge presided.

The Committee came to the conclusion that at present it appeared most convenient that some recognised society in each colony should collect all necessary matter, and forward it to the central bureau in London. The Committee of the Royal Society of London has been informed to that effect.

General Programme

THURSDAY, JANUARY 6TH.

3 p.m.—Sectional Committees meet.
4 p.m.—First Meeting of General Council at the University.
8·30 p.m.—Inaugural Meeting, President's Address at the University, and Prof. Liversidge's "At Home."

FRIDAY, JANUARY 7TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Presidential Addresses and Papers in Sections. Sections A and D at 10·30; Sections C and J at 11·30.
2 p.m. to 4 p.m.—Presidential Addresses and Papers in Sections E and H at 2 p.m.; Sections G and I at 3 p.m.
4 p.m.—Mrs. Russell's Garden Party (limited to 200 invitations).
8·30 p.m.—Arrangements to be made.

SATURDAY, JANUARY 8TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Presidential Address in Section F at 10·30 a.m.; Papers in Sections.
Afternoon Excursions.—See *Excursions Pamphlet* and Notices.

MONDAY, JANUARY 10TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Sections meet for Reading of Papers, &c.
2 p.m. to 4 p.m.—Sections meet for Reading Papers, &c.
4 p.m.—Second Meeting of General Council at the University.
8·30 p.m.—Lecture by Professor W. Baldwin Spencer, M.A., on "The Centre of Australia."

TUESDAY, JANUARY 11TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Sections meet for Reading of Papers, &c.
2 p.m. to 4 p.m.—Sections meet for Reading Papers, &c.
4 p.m. to 6 p.m.—"At Home" by Miss Macdonald, M.A., at the Women's College, University.
8·30 p.m.—Concert by the Sydney Liedertafel.

WEDNESDAY, JANUARY 12TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Sections meet for Reading of Papers, &c.
2 p.m.—Harbour Excursion.
8·30 p.m.—Lecture by Sir James Hector, K.C.M.G., M.D., F.R.S., on "Antarctica and the Islands of the Far South."

THURSDAY, JANUARY 13TH.

10 a.m.—Sectional Committees meet.
10·30 a.m. to 1 p.m.—Sections meet for Reading of Papers, &c.
12 noon—Third Meeting of General Council at the University.
Afternoon—Harbour and Dredging Excursion to Parramatta River.—See *Excursions Pamphlet* and Notices.
8 p.m.—Lecture to Working Men, by Mr. J. A. Pollock, B.Sc., on "Electric Signalling without Wires."

FRIDAY, JANUARY 14TH.

Excursions.—For particulars see *Excursions Pamphlet* and Special Notices.
8·30 p.m.—Conversazione by the Royal Society of New South Wales.

SATURDAY, JANUARY 15TH.

Excursions.—See *Excursions Pamphlet* and Special Notices. National Park and Port Hacking.

SPECIAL SHORT EXCURSIONS.

A. The Smelting Co. of Australia Works, at Dapto, on Thursday, January 20th.
Cost, railway fare only.
B. The Colonial Sugar Refining Co. Works, at Pyrmont, by tram. Jan. 13.

By special invitation.

C. Arncliffe Sewerage Outfall; Dredging Operations, Cockatoo Dock; Monier Arches, Leichhardt, by tram. By special arrangement with the Public Works Department.
D. Eveleigh Railway Workshops, by train; Hawkesbury Bridge, by train; Power House, Rushcutters' Bay, by tram or 'bus; Redfern Electrical Works, by tram. By special arrangement with the N.S.W. Railway Commissioners.
E. Garden Island. By special arrangement with the Naval Department.
F. Macquarie Lighthouse, by steamer. By special arrangement with the Marine Board.
G. Mort's Dock, Balmain, by tram or boat. By special arrangement.

Conducted under the supervision of the Engineering Section of the Association (H) on dates from January 11th to January 17th.

H. HARBOUR EXCURSION—
Leave 2·30 p.m., Wednesday, January 12th. Return 6 p.m.
I. PARRAMATTA RIVER—
Leave 2 p.m., Thursday, January 13th. Return 6 p.m.
J. NATIONAL PARK, PORT HACKING (Fishing and Botanical)—
Leaders: Fishing, Mr. J. J. Fletcher; Botanical, Mr. J. H. Maiden.
Leave, January 15th, from Redfern Railway Station, 8·30 a.m.
K. BONDI, COOGEE, AND LA PEROUSE—
Leader, Mr. Charles Hedley. January 8th, 2 p.m. by waggonettes.
WENTWORTH FALLS—Free train, January 17th.
JENOLAN CAVES—January 18th.
MOUNT KOSCIUSKO—January 19th.

ERRATA ET CORRIGENDA.

Page 99, line 1, *for* "Narrandara" *read* "Narrandera"
Page 127, line 22, *for* "*moutounées*" *read* "*moutonnées*"
Page 128, line 8, *for* "T. J. Parker, F.A.S." *read* "F.R.S."
Page 365, line 22, *for* "Nothern Asia" *read* "Northern"
Page 366, lines 3 and 15, *for* "J. M. Curran, F.R.G.S." *read* "F.G.S."
Page 366, line 9, *for* "Physiology" *read* "Physiography"
Page 366, line 13, *for* "Geographical" *read* "Geological"
Page 370 (opposite). *Plate* "xviii B." *should read* "xviii A."
Page 380, line 38, *for* "*aborescens*" *read* "*arborescens*"
Page 400, heading, *for* "Tæniopteridæ" *read* "Tæniopterideæ"

ERRATA.

In List of Vernacular Names of Australian Birds.

Page 130, No. 32A. (Hiatus.) *Supply* "Rufous Owl"
Page 133, No. 102. *For* "chloronata" *read* "chloronota"
Page 135, No. 177. *For* "Field-Lark" *read* "Field-Wren"
Page 135, No. 199. *For* "guttaralis" *read* "gutturalis"
Page 135, No. 205. *For* "castonothorax" *read* "castoneothorax"
Page 138, Nos. 285 and 286. *Transpose* vernacular names.
Page 139, No. 333. *For* "pencillata' *read* "penicillata"
Page 140, No. 371. *For* "guadragintus" *read* "quadragintus"
Page 144, No. 461. *For* "Psittenteles" *read* "Psitteuteles"
Page 145, No. 522. *For* "Orange-throated" *read* "Scarlet-chested"
Page 147, No. 566. *For* "brachypus" *read* "brachipus"
Page 149, No, 608. *For* "Cladorhyncus" *read* "Cladorhynchus"

ADDRESS

BY

A. LIVERSIDGE, M.A., LL.D., F.R.S.,

PRESIDENT,

At the Seventh Session of the Australasian Association for the Advancement of Science,

JANUARY 6, 1898.

FIRST of all I wish to apologise for being a pluralist, although I am one very much against my wish, as well as against my principles—neither post can, however, I think, be regarded as a sinecure. As I said on a previous occasion, it would have been ungracious on my part to have persisted in my disinclination to accept the distinguished position in which you have placed me to-night. With regard to the other office, I found no one willing to relieve me, and I felt that it would be cowardly to slink away from its duties by resigning; under the circumstances, I can only hope that the Association will not suffer in consequence.

This address, such as it is, has been prepared under considerable difficulties, while occupied with many other duties, and I beg your forbearance accordingly.

It is a very usual practice for the President of the British Association to pass in review the advancements made in science since the previous visit of the Association to the particular town in which the meeting is being held, or else to give an account of the progress made in his own special branch of study.

The course followed by our own Presidents has usually been to give an account of the history and progress in Australia of some branch of science, such as Astronomy,

Geographical Exploration, or Geology. I shall not attempt to do this for Australasian chemistry, because the chemical work done here is perhaps both of too fragmentary and of too technical a character for a general audience.

But first of all it is my painful duty to state that since we last met we have lost three of our most prominent officers.

SIR ROBERT GEORGE CROOKSHANK HAMILTON, K.C.B., LL.D.,

who was President of the Association of the 4th session, held at Hobart, 1892, was born at Bressay, Shetland, and educated at Aberdeen, and was Governor of Tasmania from 1886 to 1893.

Sir Robert did much to promote the advancement of science in Tasmania, and was President of the Royal Society of Tasmania, from 1886, until his retirement from the Governorship in 1893. He took great interest in the meeting of this Association, held in Hobart, in 1892, and much of the success of that session was due to his personal efforts in making the preliminary arrangements, and to the active part he took in the proceedings of the Tasmanian session. His death took place in London, in April, 1895.

BARON SIR FERDINAND VON MUELLER, K.C.M.G., F.R.S.,

who died last year, was our President at the Melbourne session, the second meeting of this Association, and a most helpful member in furthering our objects.

An account of the life and labour of the Baron would take too long for such an occasion as this. The mere enumeration of the titles of his works and papers run into many pages of the Royal Society Catalogue of Scientific Papers.

He was born at Rostock in 1825, educated in Schleswig, and studied the botany of Schleswig and Holstein from 1840 to 1847. He came out to Australia in that year on account of threatened lung trouble, and made botanical expeditions

through South Australia from 1848 to 1852. In 1852 he was appointed Government Botanist to Victoria, and held the position until his death in 1896. He was occupied in botanical exploration from 1852 till 1855, especially in the Alpine regions, the vegetation of which was till then unknown; he also made extensive explorations in the northern parts of Australia, and accompanied the overland expedition conducted by Mr. A. C. Gregory, our retiring President.

While Government Botanist and Director of the Melbourne Botanic Gardens from 1857 to 1873 he did much to introduce new and useful plants into Victoria and to distribute Australian plants to all parts of the world. He was a member or honorary member of very many (150) scientific societies, and received numerous Royal decorations and similar honours. His loss to Australia is a very great one, and the vacancy he has left amongst botanists here will be hard to fill; in his capacity for work and devotion to it he was one in millions. He was not less distinguished for his amiability and generosity, and was almost too ready to give from his very slender means to assist those in distress, and for the advancement of botanical science.

The Government of Victoria provided a plot of ground for his last resting-place, and funds are being collected for the erection of a monument. It is also proposed to establish some permanent memorial of the Baron, and the members of the Association will have an opportunity of subscribing towards that very desirable object. It is hoped that sufficient funds will be collected to provide a bust, and to endow a medal, prize, or scholarship in recognition of meritorious botanical work carried out in these Colonies.

PROFESSOR T. JEFFREY PARKER, D.Sc., F.R.S.

We have by the lamented death of Professor Parker lost the President elect for the Biological Section and our Local Secretary for New Zealand, which latter office he has held since Captain Hutton's resignation in 1891.

Professor Parker was a younger son of the well-known Dr. W. K. Parker, F.R.S., Professor of Anatomy in the Royal College of Surgeons, and was born in London in 1850; he received his scientific education at the Royal School of Mines, London, where we were friends and fellow-students. He was Demonstrator of Biology under Professor Huxley at the Royal School of Mines and Royal College of Science; also Lecturer in Biology at Bedford College, London; an Examiner for the University of Aberdeen, and for the Science and Art Department, South Kensington, and came out to Otago University some seventeen years ago (1880) as Professor of Biology and Curator of the Museum, and was elected a Fellow of the Royal Society in 1888. His "Zootomy" is a well-known practical hand-book for students, and his "Elementary Lessons in Biology" is deservedly popular; the latter has passed through several editions, and has been translated into German. He was also author of many papers published in various scientific journals, including the Transactions of the Royal Society, London, and he had in conjunction with Professor Haswell just finished a text-book of zoology, probably one of the best of its kind that has yet been written. Professor Parker also introduced a valuable process for preserving and exhibiting the cartilaginous skeletons of fishes, which is now largely used in most museums in all parts of the world.

Many of our biological members were looking forward to meeting Professor Parker, some as old friends, while others wished to make his acquaintance; all will regret his absence most keenly.

He died on the seventh of November last, at the comparatively early age of 47, cut off in the full career of his matured and best work.

Professor Parker's work is probably far better known in Europe and America than it is in Australasia, for the number of people here who can appreciate work such as

his is necessarily very limited, but in later generations there will probably be more to do so, for much of it is of the kind which will survive and keep his memory green.

The Council has already sent a resolution of sympathy to Professor Parker's family, and many other scientific bodies in Australia have also done so.

Inasmuch as our aims and objects are similar to those of the British Association, our constitution having been framed upon the same lines, it appears to be both desirable and appropriate that our members should have some knowledge of what the parent institution has done, and is doing; hence, in the first instance, I wish to briefly draw your attention to it; next, to touch upon certain matters connected with the work of our own Association, for I think it is very important that such topics should be referred to in an address of this kind. The opening meeting of the session is almost the only opportunity, and it is certainly the most fitting occasion to review what we have accomplished and to consider what we might do for the advancement of science, especially as it is now ten years since we held our first and inaugural meeting in Sydney. Personally, I am inclined to think that matters of this sort are of even more importance to our members, particularly to the new ones, than an account of recent scientific discoveries, for such can only be given in a very bald way, and, moreover, they are duly chronicled in the scientific journals for the use of specialists, and some sort of account of them is given in magazines and newspapers for the benefit of the general reader, whereas but little is published in a collective form of the general work of such Associations as this.

Following next in order I think of referring to certain other institutions for the advancement of science, and then finally to say something about certain recent discoveries and advances in chemistry.

THE BRITISH ASSOCIATION.

The British Association was instituted at York in 1831, at a meeting held at the suggestion of Sir David Brewster, in the Hall of the Philosophical Society of Yorkshire, with the title of "The British Association for the Advancement of Science," and its objects were "to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the British Empire with one another, and with foreign philosophers; and to obtain a greater degree of national attention to the objects of science and a removal of any disadvantages of a public nature which impede its progress." It has met regularly every year in some town of the United Kingdom, except that in 1884 it met at Montreal, in Canada, and in August last it again met in Canada, this time in Toronto. The American Association held its Session at about the same time at Detroit, so that the members of both Associations might have opportunities to meet.

The Mayor and Corporation of San Francisco invited the members of the British, the American, and Australasian Associations to meet together at San Francisco, after the British and American Association meetings; the Australasian Association was, unfortunately, unable to accept the very cordial invitation to join in this first attempt at an International gathering.

The Mayor's letter of invitation contains the following passages:—

"It is my sincere hope that San Francisco may have the good and rare fortune to receive the visit of all three of these distinguished bodies.

"Its citizens will feel honoured in extending a generous welcome to men eminent in the cause of truth and representing the three great branches of the Anglo-Saxon race."

The British Association meets for a week or ten days once a year. Its work is opened by an address from the

President on the evening of the first day; on the following days the various sections commence their sittings, and their work is, in each case, also opened by an address from their respective Presidents; next, papers and reports from the various committees appointed to conduct scientific researches during the preceding year are read, followed by discussions upon the same. These discussions form one of the most valuable features of the British Association's meetings.

The sectional meetings are held from 10 a.m. to 4·30 p.m., after which there are usually short excursions to places of interest to the geologist, botanist, chemist, antiquarian, and others, and in the evenings there are lectures and conversaziones; also receptions and entertainments given by the residents and local bodies to the members.

The social entertainments cannot be looked upon as mere pleasure-making functions; they perform a real part of the work of the Association, as they enable the members to meet, and make the acquaintance of others from outside of their own special sections, and much good is done thereby, as it tends to break down some of the barriers of specialism.

The principal cities of the United Kingdom emulate one another in the cordiality of their invitations for the Association to become their guests; and the formal invitation is sometimes made by a deputation consisting of the Mayor and members of the Corporation, and prominent residents, sent for that special purpose. Thus at the Liverpool meeting there were deputations from the cities of Bristol and Glasgow, to press their invitations. The local authorities make arrangements to defray a large part of the expenses of the meeting, and the whole of the expenses of the various entertainments; so that the income of the British Association is free to be spent upon its scientific objects. The meetings are arranged for two years in advance, and as invitations are usually offered for several places at once, a selection has to be made.

The meeting of the British Association is usually considered to be an advantage to the town visited, and the surrounding district. One advantage is that local men become better acquainted with those from other parts of the kingdom and with foreign men of science, for it is one of the good features of the British Association to invite a certain number of distinguished foreigners as guests for each meeting.

Museums, ancient monuments, cave-dwellings, and other similar local objects of interest, if such exist, usually receive attention, and in many cases with most beneficial results.

The peripatetic character of the British Association meetings is one of its best and most useful features, and its visit usually permanently raises the local interest in scientific matters to a higher level.

The results of the work of the Session are printed in the form of an Annual Report of 1,200 to 1,500 pages. In it appear the addresses of the President and Presidents of the sections; also the reports of the Scientific Research Committees. On account of the great number of communications, papers read before the Sections are usually printed in brief abstract, or the title only is given. The work done covers nearly all branches of Science, and the Research Committees have members carrying out investigations in all parts of the world, and in some cases their labours extend over many years.

The British Association has, since its foundation, granted over £63,000 to assist individuals and committees in their researches. The grants commenced in a very moderate way, in 1834, with a vote of £20 for the investigation of Tides; since then they have gradually increased, and now the amount usually exceeds £1,000 a year.

In 1899 the British Association is to meet at Dover, and the French Association at Boulogne, on the opposite coast, during the same week, with the express object of an

interchange of visits between the two Associations. This will do much to make the scientific men of the two countries better acquainted with each other, and what is of more importance, with each other's work for the common end, viz., The Advancement of Science.

THE AUSTRALASIAN ASSOCIATION.

The meetings of this Association are conducted upon similar lines, but as our President and most of the officers and members are necessarily resident, the visits of the Association are not of so guest-like a character as those of the British Association.

I need hardly remind you that the Australian Association held its first meeting in Sydney, from 27th August to 5th September, of the Centennial year, 1888, under the Presidency of Mr. H. C. Russell, C.M.G., F.R.S., with a roll of 850 full members. Meetings have since been held in Melbourne in 1890, with 1,162 full members, when the late Baron von Mueller, K.C.M.G., F.R.S., M. and Ph.D., was President; at Christchurch, N.Z., in 1891—President, Sir James Hector, K.C.M.G., M.D., F.R.S.; at Hobart, in 1892—President, His Excellency Sir Robert Hamilton, K.C.B., LL.D.; at Adelaide, in 1893—President, Prof. Ralph Tate, F.G.S., F.L.S.; and at Brisbane, in 1895, when the Hon. A. C. Gregory, C.M.G., M.L.C., F.R.G.S., was President.

The Government of New South Wales provided for the printing of the first volume, and the Governments of Victoria, Tasmania, New Zealand, South Australia, and Queensland, have each in turn given liberal assistance, both by money grants and in other ways, towards the expenses of the Session, and by printing the volume of reports and papers.

The Association has up to the present published 6 volumes of reports, each of about 1,000 pages, containing much important matter; it has appointed Committees for the

investigation of the following subjects; all have furnished reports, which being of permanent value, have been printed, viz.:—

1. The Establishment and Endowment of a Biological Station for Australasia.
2. Certain points in the Construction and Hygenic Requirements of Places of Amusement in Sydney.
3. A Census of Australasian Minerals.
4. Glacial Evidence in Australasia, £20 granted towards the expenses.
5. Town Sanitation.
6. The Seismological Phenomena of Australasia (£10 granted in aid of this research).
7. A Bibliography of the Australasian and Polynesian Races.
8. The question of Antarctic Exploration.
9. The State and Progress of Chemical Science in Australia, with special reference to Gold and Silver Saving Appliances.
10. The Question of Rust in Wheat.
11. The Location and Laying-out of Towns.
12. The Improvement of Museums as a means of Popular Education.
13. The Fertilisation of the Fig in the Australasian Colonies.
14. The Unification of Colours and Signs of Geological Maps.
15. The Tides of Australia (The Tides of the coast of South Australia).
16. Polynesian Bibliography, with special reference to Philology.
17. The Protection of Native Animals.
18. Glacial Action in Australasia during Tertiary and Post-Tertiary Eras.
19. The Photographing of Geological Surveys.
20. The best means of encouraging Psychophysical and Psychometrical Investigation in Australia.

It has also granted the sum of £25 towards the ascertainment of movements of New Zealand glaciers, and £10 towards the cost of the erection at Timaru of the Seismological instruments, presented by Dr. Von Rebeur-Paschwitz. It has secured (1) from the New Zealand Government the reservation of the Little Barrier Island, and Resolution Island, Dusky Sound, as suitable localities for the preservation of Native Flora and Fauna. (2) In response to a recommendation from the 1891 Session, it was agreed by the Lords of the Admiralty, that the sea between New Zealand, and the islands to the N.W. of New Zealand on the one hand, and Australia and Tasmania on the other, be known as the Tasman Sea, and that the name is to be entered on the Admiralty charts. (3) Further, through the instrumentality of the Association, the New Zealand Government has set apart Stephen's Island, Cook Strait, as a reserve for the Tuatara Lizard, and (4) Correspondence has been received from the Governments of Tasmania, New South Wales, New Zealand, and Victoria, in which sympathetic acknowledgment is expressed towards the wishes of the Association in regard to resolutions, passed at its last Session (in Brisbane), viz., to bring before the Australasian Governments that it is desirable :—

(*a*) That a system of compulsory notice of infectious diseases be introduced.

(*b*) That a system of Federal Quarantine be introduced.

(*c*) That stock, the milk or flesh of which is intended for consumption, be examined by duly qualified men, and slaughtered, if found Tuberculous or Cancerous.

At the last Session (Brisbane, 1895) a number of research committees were appointed, some of which will report during the present Session. Chief among these may be mentioned :—

1. For the investigation of Glacial Deposits. (Reappointed.)

2. The Seismological Committee, to investigate earthquake phenomena in Australasia. (Reappointed.)
3. To consider and report upon the Thermo-dynamics of the Voltaic Cell.
4. The geology, land flora, land fauna, and natural resources of the islands and islets of the Great Barrier Reef.
5. The habits of the teredo, and the best means of preserving timber or structures subject to the action of tidal waters.
6. The Committee to give effect to the suggestions contained in Sir Samuel Griffith's paper entitled "A Plea for the Study of the Unconscious Vital Processes in the life of a community."

AUSTRALIAN BENEFACTIONS TO SCIENCE.

In connection with the efforts made for the advancement of science in Australia we should not overlook the recent generous gift made by Mr. P. N. Russell of £50,000 for the support of our Engineering School, for instruction in pure and applied science. This is, perhaps, one of the best ways of supporting the objects of this Association, *i.e.*, by providing a scientific training for students, who may develop into men of science.

Then there is the bequest made by Sir Thos. Elder to the Adelaide University, of which a large portion goes to support the Mining and other scientific schools.

Also the scientific expedition to Central Australia, which was despatched by Mr. Horn from Adelaide at great expense. We shall have the pleasure of hearing of some of the results of this act of public-spirited generosity from Professor Spencer, who is kindly giving our members a lecture upon Central Australia.

Next there is the expedition from the Royal Society of London, under Professor Sollas, to investigate the structure of a coral reef by boring, to which this Colony contributed liberally in men, money, and material.

During the past year this has been supplemented by another expedition from Sydney under the charge of Professor David, largely at the cost of residents in this Colony and the New South Wales Government. The Royal Society of London has again provided a large portion of the requisite funds.

I do not propose to go into the matter, as I have no doubt a full report will, in due course, be issued by Professor David; meanwhile, I think we should express our pleasure at the safe return of the expedition, and our gratification at the success which has so far been achieved, especially as the operations had to be carried out under considerable difficulties.

PROVINCIAL SCIENTIFIC SOCIETIES AND INSTITUTIONS.

Outside the capital of New South Wales scientific societies and institutions are practically non-existent, and I think this is also the case with respect to the other colonies of Australasia, except New Zealand.

New Zealand sets Australia a good example, for although its population is only about one-half that of New South Wales, it has comparatively large and active scientific societies in Auckland, Christchurch, Dunedin, Napier, Nelson, Wellington, and Westland. All of these are separate and independent societies, but collectively they form the New Zealand Institute, centred in Wellington. Papers read before the local societies, if of sufficient merit and importance, are published in the Transactions of the New Zealand Institute; this is an exceptionally wise plan, for the smaller societies could not afford the expense of publishing separate annual volumes; further, the papers are distributed more widely and a better standard can be maintained. If there were similar local societies in Bathurst, Broken Hill, Goulburn, Newcastle, and other towns in New South Wales, which are quite as large as some of the New Zealand towns, they could do much for the advancement of science, and assist the aims and objects of this Association.

I have spoken more particularly of this Colony, but of course the remarks also apply to the larger towns of the other colonies, where there are no local societies. Such societies could probably, if they existed and so wished, be affiliated to the Royal Society of New South Wales or of Victoria, South Australia, or Queensland, and to this Association. The British Association has a system of corresponding societies, who send delegates to its meetings.

It is a very great pity that such societies do not exist in our provinces, not only for the benefit of the local residents but also for the cause of science generally.

At present this Association has to depend very largely upon the members of the staffs of the universities, observatories, museums, the geological surveys, and certain other Government departments, and most of these, with the exception of those resident in the capital in which the Session is held, have to undertake a journey of 500 or 600 miles, or even 1,200 miles, as in the case of those who attend from New Zealand, or who, living in Brisbane, attend a meeting in Adelaide, or *vice versâ*.

These very long distances are a great disadvantage to the Association, for they mean a considerable expenditure of time and money, and many are thereby debarred from attending. It is largely due to these causes, as well as to the limited number of working members, that we have had most reluctantly to substitute biennial for annual sessions. If we had more working members, and I think we should get them if there were local scientific societies scattered through the Colonies, we should be able to resume our annual meetings, and before very long we ought to be able to hold our Sessions in towns like Ballaarat, Bathurst, Bendigo, Goulburn, and Newcastle.

For the formation of local societies it is not necessary to start with a large membership—the Royal Society of London began with five or six only.

It is, however, very gratifying, under the circumstances, and with our comparatively limited population, that our meetings are as well attended and successful as they are.

INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

An International Conference was held in London in 1896, from July 14th to 17th inclusive, for the purpose of arranging for an International Catalogue of Scientific Literature, which was attended by representatives nominated by the Governments of most European countries, as well as by those of America, Japan, Mexico, India, and the Colonies. I had the privilege of attending this Conference, first as one of the representatives of the Royal Society of London, and afterwards as the representative of the New South Wales Government.

The work intrusted to it is of a most important character, and if carried to a successful issue will be of the utmost benefit to workers in every branch of science, and one of the greatest possible aids to its advancement.

In 1864 the Royal Society commenced its Catalogue of Scientific Papers, arranged according to the names of the authors, and it has now by the aid of Government grants published eleven bulky volumes; it is found, however, that a catalogue according to subjects is of even greater necessity; but such an undertaking is beyond the power of any one society or even country, hence the necessity for international co-operation.

A committee was appointed by the Royal Society in 1893 to communicate with societies and institutions at home and abroad with reference to the preparation, by international co-operation, of complete catalogues of scientific literature, arranged both according to subjects and authors.

A circular letter approved by the President and Council was sent to 207 societies and institutions, and to the Directors of Observatories and of Government Geological Surveys, and a special letter was sent to the Smithsonian Institute.

It was pointed out that the existing Catalogue of Scientific Papers was limited to periodical scientific literature, and that the titles of books and monographs were not included, also that the titles were arranged merely by the authors' names.

The replies were numerous, and in most cases warmly supported the suggestions; they also referred in the highest terms to the value of the Royal Society's Catalogue of Scientific Papers.

The Smithsonian Institute and other American bodies also took up the matter most cordially, and offered many valuable suggestions for carrying out the details of the work.

After a report had been received from the Committee, the Council of the Royal Society approached the Marquis of Salisbury, the Minister for Foreign Affairs, and suggested that the British Government should invite certain other named Governments to appoint delegates to an international conference for the purpose of considering the matter.

Favourable replies were received and a large number of delegates appointed, all of whom attended the Conference in July, 1896, except the delegate from Russia, who was absent from illness.

The Right Hon. Sir John Gorst, Q.C., M.P. (V.P. of the Committee of Council of Education), representing the British Government, was unanimously elected Chairman, and he afterwards welcomed the delegates.

Nearly all the resolutions are given (see page 51) because they should be known by our members, in order that we may be in a position to consider the matter, with the view, if possible, of co-operating in so very important an undertaking. Every person in Australasia and elsewhere who is the author of a published paper upon any branch of pure science should take an interest in this matter, because he will in future probably be required to prepare an index of

the contents of his paper for publication by this Committee, or failing that to run the risk of his work being ignored.

A catalogue such as is proposed would be of even greater value to students of science in Australasia than to those in Europe and America, since we are so much farther removed from the great centres of thought and activity, and, moreover, we are debarred from access to any scientific library which can in any way be considered as complete, even in any one department. From the proposed catalogue we should be able to see what has been published, and having learnt of the existence of a given memoir or treatise, we should be in a better position to take steps to procure it; at present we are often in the dark, and have but imperfect means of learning what has been published upon any particular subject.

A long and instructive discussion took place over the method of classification. It was considered by many that the Dewey Decimal system could not be adopted unless modified, although it is used by the International Conference on Bibliography at Brussels and by many libraries; its merits for the use of librarians are not denied, but it is not suitable for scientific catalogue purposes. Dr. Billings stated that it is simply a shorthand method for the classification of books on the shelves, and rapidly finding them, and is not adopted in any Government Library in America, nor in any University library except Albany and Columbia, in both of which Mr. Dewey had been librarian. Eventually the study of classification was referred to the Committee of Organisation.

When the question of the language was under discussion, Professor Mach, representing Austria, proposed the use of English as the sole and only language, because English is so widely spoken over the civilised world. He said everyone should respect his own nationality and his own language, but before that they should consider the universal interest of mankind. It was unanimously agreed, on the motion of M. Deniker, representing France, and General Ferrero, the

Italian Ambassador, representing Italy, that the catalogue should be in English.

Since the meeting of the Conference in July, 1896, "a Provisional British Catalogue Committee" has been appointed, which might be consulted by the Committee of the Royal Society, on questions relating to the collection and preparation of the material supplied by the scientific literature of Great Britain and Ireland, and which might ultimately develop into the National Bureau for the United Kingdom.

A committee of nearly forty representatives from the principal British societies and libraries has been constituted. This committee is to inform the Committee of the Royal Society,—

1st. As to the best method of collecting the material for the catalogue in Great Britain and Ireland.

2nd. Whether each society will undertake the collection and preparation of the material of the science which it represents.

3rd. Whether each society will bear, either wholly or in part, the expenses of such collection and preparation.

At the first meeting of the British Committee it was practically agreed that all the special societies and institutions represented would co-operate in the work of the International Catalogue.

In Austria and Germany conferences have been held of representatives from the principal scientific societies and institutions, and it has been agreed to co-operate in the work; the Austrian Ministry of Education has in principle expressed its willingness to further the work and to ensure its due execution. The future action of the German Government appears to be dependent upon the question of the probable cost, and upon certain minor details. It has, however, probably decided by now. The steps to be taken by the other Governments will also soon be known.

In the interim statement from the Royal Society Committee, for the information of the delegates of the 1896 Conference, it is pointed out that "it is absolutely necessary to each scientific society, and to the editors of every serial scientific publication, to index for their own purposes whatever they publish, and the only change in the existing system required for the purposes of the International Catalogue is that each paper shall be fully indexed at the time it is passed for press." If such material be forwarded at the earliest possible moment to the body primarily interested in its collection, and after revision to the Central Bureau, no time need be lost.

Of course all material thus collected will have to be prepared for publication on a uniform plan. It is pointed out that under such a system the material will automatically flow into the proper channels.

The committee regards it as essential that authors should be requested to supply indexes of the subject-matter of their papers; some, of course, may supply too much information, and others too little, but from the experience already gained in the office of the Royal Society it is clearly shown that the information supplied by the authors is of the greatest value to the supervisors of the work of indexing.

The International Conference arranged that the Central Bureau should issue the catalogue in book form from time to time, in parts or divisions for the various branches of science, and also, as promptly as possible, in the form of "slips" or "cards." The committee are of opinion that the National Bureau of each constituent country should prepare the slips ready for the slip catalogue.

The committee wish opinions upon the question as to whether the co-operating countries should have the option of printing and also of issuing the slips which it prepares to subscribers within its own limits. This is a point which might well be discussed here, together with others, during the session of this Association.

The Senate and House of Representatives of the United States have already voted the sum of $10,000, or £2,000, per annum for the clerical and other expenses connected with the cataloguing of the scientific publications of the United States, the same to be expended under the direction of the Secretary of the Smithsonian Institute.

Australasia ought certainly to do something towards the cataloguing of its scientific publications, and in order that the matter may be considered by representatives of the principal Australasian Colonies, I have taken steps to bring the question before the General Council during the present session.

I have dwelt rather fully upon this subject of an International Catalogue of scientific literature, because I think that a session of the Australasian Association for the Advancement of Science is the most favourable opportunity of bringing the matter under the notice of those interested in science in Australasia, and because I am strongly of opinion that it is a work in which this Association, both collectively and individually, should take an active part.

THE IMPERIAL INSTITUTE.

It is satisfactory to find that the Imperial Institute, London, is becoming an institution for the advancement of science. When in London, in 1896, I had many opportunities of seeing and inquiring into its working.

The Scientific Research Department, under Professor Wyndham R. Dunstan, F.R.S., was opened in October, 1896. Towards this Department the Royal Commissioners for the Exhibition of 1851 contribute £1,000 per year. The Goldsmith's Company has also made a second grant of £1,000 towards providing the accommodation and equipment; the Salters' Company has founded a Research Fellowship of £150 a year, and in October, 1896, the staff of assistant chemists employed was increased to eleven. The Government of India also gives an annual grant for research work upon Indian medicinal plants, dyes, gums, tanning materials, coal, and other products.

Canadian and Cape minerals and other products have been under investigation, also Cape and Australian wines have been chemically examined and reported upon. Reports from manufacturers and experts upon the probable commercial value are also obtained at the same time.

Amongst the scientific referees are Prof. Church, F.R.S., on cereals; Prof. Armstrong, F.R.S., on terpenes and volatile oils; Prof. Unwin, F.R.S., and others, on the strength of materials; and Prof. Judd, C.B., F.R.S., on minerals.

There is a department for commercial intelligence, also for collections of minerals and products from India, Canada, Australia, and the other Colonies, which are utilised for instruction by the curators lecturing upon their contents on certain days, of which public notice is given.

Further free public lectures are given upon the Colonies, and these are very largely attended by appreciative and rapidly-increasing audiences, composed mainly of working-men.

Collections of Colonial products are, where the supply of material is sufficient, being made up and distributed to provincial districts. Twenty-four collections were sent out last year, and more will be made up and sent out on receipt of material from the Colonies. These will do much to disseminate a knowledge of the Colonies throughout the United Kingdom.

Further, there are courses of evening lectures once a week for the Fellows and their friends during the winter.

A journal is published monthly, devoted to the work of the Institute and to Indian and Colonial matters which are likely to promote the objects of the institution.

There is no doubt that the institution is now fulfilling one of its intended objects, and is becoming a most valuable means of disseminating a knowledge of the products and manufactures of the Indian Empire and of the Colonies,

not only of a commercial but also of a scientific value, and the Australasian Colonies ought to be particularly interested in its work.

Like many another institutions, its income is inadequate for the work in hand.

CHEMISTRY OF THE ANCIENTS.

I think we may include amongst the recent advancements of science the six important volumes (2,600 pages) upon the History of Chemistry, recently published by Prof. Berthelot, of Paris (Perpetual Secretary of the Academy of Science, and sometime Minister of Foreign Affairs), since they form a notable addition to the history of chemistry, and set us right upon many matters.

My remarks are condensed from a paper by Dr. Carrington Bolton, read before the American Chemical Society, inasmuch as I have not had time to do much more than glance through the volumes themselves. In them M. Berthelot gives an account of the ancient Greek alchemists and of the chemistry of the Middle Ages. These volumes contain many of the most ancient Greek, Arabic, Syriac, and Latin writings upon technical chemistry and alchemy, treasured in the great national libraries of Europe. The task must have been an enormous one, and was, of course, only possible with the assistance of scholars well versed in old manuscripts in those languages, aided bv the substantial assistance of the French Government.

Some of the Greco-Egyptian manuscripts have but little bearing on chemistry, being devoted to magic, incantations, dreams, signs, etc., but others relate to the working of metals, and the preparation of gold and silver, of alloys, the soldering and colouring of metals, and similar industrial matters.

Berthelot thinks that the idea of the transmutation of metals arose from the attempts of goldsmiths and others to

make fraudulent substitutes for gold and silver, and not, as is commonly thought, from any scientific views concerning the constitution of matter.

The Greek writers knew something of many ores, minerals, and saline substances, but nothing of mineral acids and their salts, nor had they any systematic scientific knowledge—they merely knew more or less imperfectly certain isolated facts and processes.

Berthelot traces the filtration of alchemy and allied matters from the Greeks, through the Syrians to the Arabs. The Arabian treatises, which found their way to Spain, were translated into Latin; from these Latin translations the natives of Europe acquired their knowledge of philosophy, mathematics, alchemy, and medicine.

Some of the Greek knowledge of alchemy, however, was translated directly into Latin during the time of the Roman Empire; many of the writings are merely workshop receipts; one, a formula for working bronze, gives the origin of the name bronze, *i.e.*, "De Compositio Brandisii," Brindes or Brundusium; Brindisi (modern), being in Pliny's day noted for metallic mirrors.

Berthelot found that the reputed Arabic originals of many Latin translations never had any existence, and this is especially the case with some of the chemical works supposed to have been written by Jábir ibn Hayyan (Abu Musá), an Arabian physician, usually known as Geber.

Geber lived in the ninth century, and some of his writings are preserved in Paris and Leyden, but they differ from the versions attributed to him in Latin, French, German, and English. The treatises on alchemy by Raymond Lully are also spurious.

The Arabians have been given credit for chemical knowledge which belongs to a period 500 years later, and the history of chemistry has been in consequence falsified to that extent.

It may be remarked incidentally that the term "Philosopher's Stone" does not occur until the seventh century, although the idea is much older.

The pretended translations from Arabic treatises into Latin often contain references, to give them an air of authority, to mythical persons, and these, by later writers, are taken without verification, hence faith in the works of Morien, Kalid, Zadith, and others, must be relinquished.

Jábir, or Geber, was the chief of the Arabic alchemists, and is said with Oriental exaggeration to have been the author of 500 treatises (six of these are collected and translated); he had knowledge of the hydrostatic balance, and of many minerals, which he ingeniously classified; but he makes no mention of the mineral acids, of silver nitrate, and other chemicals with which he was supposed to be acquainted.

In his "Book of Mercy" he cynically says, "I saw that persons engaged in attempts to manufacture gold and silver were working ignorantly, and by wrong methods. I then perceived that they were divided into two classes—the dupers and the duped. I had pity for both of them."

In connection with the foregoing, it may not be amiss to refer to the account which Dr. Carrington Bolton gives of two American cases of modern alchemy, for it certainly shows in the latter of the two cases that similar ignorance still exists, as in Greek and in mediæval times.

In 1896, Dr. Stephen H. Emmens claimed to have converted silver into gold, and still claims to be able to make the conversion, mainly by "the combined effect of impact and a very low temperature," and he states that from 1 oz. of silver he can obtain $\frac{3}{4}$ oz. of gold, by which he makes a profit of about 3 dollars, or 12s. upon each oz. of silver employed; but, as the process is secret, there is no means of verifying his statements, which have been running the round of newspapers throughout the world.

Mr. E. C. Brice is the second claimant for a process of converting base metals into precious ones; but, on putting his process for transmuting lead, tin, antimony, and other metals into gold to the proof, it was found that the base metals used contained traces of gold, as they always do, and that under the rigid supervision of the officials at the Washington Mint, Mr. Brice obtained less gold from them than the small quantities which they really did contain.

THE TEACHING OF CHEMISTRY.

The London County Council appointed a special committee of its Technical Education Board to inquire into the teaching of chemistry, and after hearing evidence from witnesses well versed both in the German and English methods, and fully considering the results obtained, they arrived at the following chief conclusions :—

1st. That the teaching in schools should be solely of an educational character, and should have no reference to practical, *i.e.*, technical application in later life.

2nd. Chemistry, pure and simple, is a most valuable means of education, and requires to be largely imparted by means of laboratory work, *i.e.*, experimental exercises.

3rd. That too frequent examinations of young students gives rise to great evils.

4th. The preparation of the technological chemist should extend over several years; it should be of University standard and include original research.

A report to the Council on Education by Sir Philip Magnus, and his colleagues on Technical Education in Germany, supports the above-cited report, and it lays great stress upon the very great advantage which Germany has derived from its systematic application of science to industry.

Australia at present imports most of its scientific men, but it is time that it set about educating its own in greater numbers, and providing greater facilities and better-equipped laboratories than the existing ones.

Our courses in science should all be of at least four years in length, and then there should be in all subjects special post-graduate and honour courses. Until this is done we can hardly hope to train our own teachers.

In this respect we are behind Europe and America, where the courses for all professional and scientific schools are usually from four to five years in length.

It has been said by a writer in the *North American Review* :—"It is fair to hold that the country that has the best chemists will, in the long run, be the most prosperous and the most powerful. It will have at the lowest cost the best food, the best manufactured materials, the fewest waste and unutilised forms of matter, the best guns, the strongest explosives, and the most resistant armour.

"Its inhabitants will make the best use of their country's resources ; they will be the most healthy, the most free from disease ; they will oppose the least resistance to favourable evolution ; they will be the most thrifty and the least dependent upon other nations. The education of the people in chemistry and the physical sciences is the most paying investment a country can make. Competition to-day between nations is essentially a competition in the sciences and application of chemistry."

Students require to be taught not only the principles of science, but also how to observe, how to use their hands, and to reason and think accurately, and to gather their information from various sources, for there are but few, if any, text-books so well written as to be of equal value in all parts. And especially should they have time and opportunity for some original or research work in order that they may enlarge the borders of knowledge and contribute something, however small, to the common stock, for, as

pointed out by Sir W. Roberts, M.D., science has one advantage over literature and art, viz., that whatever advance is made by a master mind can be used as a stepping-stone for the next advance by those who come after him, even if they be somewhat inferior; in art much depends upon individual taste and skill, which cannot be placed on record in black and white. By the study of the old master-pieces an artist cannot set to work and make an advance upon them; but in science a well-trained scientific man, if he has the time and opportunity, can usually improve, even if only to a slight degree, upon the work of his predecessors.

Mere training and teaching for a degree is not sufficient; post-graduate work is essential if we wish to turn out scientific men who will be able to "advance Australia" by developing its resources and improving the conditions of life. It is not sufficient to merely instruct in the facts and principles of scientific knowledge—it is most important also to impart scientific habits of thought and methods, especially with the object of making new investigations or researches, so that the student may in turn be able to acquire something more than he himself was taught, or had learnt from books.

Our students cannot, as a rule, spare the time and money, but have to put what knowledge they acquire to a money-making use as soon as possible. The University greatly needs funds for studentships, to be held by graduates, so as to help a few of the most promising to spend an additional year or two in doing some real solid work, after they have been duly trained in the lecture-room and laboratory, for the first degree.

The arguments as to the necessity for students to do some original work, wherever possible, apply still more strongly to the teaching staff.

Professor Michael Foster, Secretary of the Royal Society, in his address to the British Association at Toronto, says:—

"Never so clearly has it been recognised that each post

for teaching is no less a post for learning, that among academic duties the making of knowledge is as urgent as the distributing of it, and that among professorial qualifications the gift of garnering in new truths is at least as needful as facility in the didactic exposition of the old ones."

The proportion of professors and other teachers to the number of students is much smaller in Australian than in European Universities, and the time and facilities for research are less.

From the report of the United States Commission for Education, 1896, it appears there are seventy-five higher seats of learning in Germany, Austria, and Switzerland, having altogether 5,963 professors, 67,062 students, and 6,628 foreign students.

In Germany there is one professor for 12·1 students, and an average of 78·4 professors and 926·3 students (of whom 67·2 are foreigners) to each seat of learning. Austria has one professor for 11·7 students. In Switzerland there is one professor for 5·9 students.

Cambridge was about to make, in 1896, and probably has made by this time, very important changes to encourage the higher study of science, by establishing regulations for the admission of graduates of other Universities, who are not already members of the University, as "advanced students," upon a superior footing to ordinary undergraduates.

They may pursue courses of advanced study or research, literary or scientific, under the direction of University teachers, without following the usual courses of study and examinations required for degrees in the University. They may also become members of certain colleges without fulfilling the conditions imposed on junior students, and their college status is assimilated to that of students who have taken their first degree in the University.

SOME NEW CHEMICAL ELEMENTS.

Argon and helium are two of the latest additions to the list of chemical elements, and Sir J. Norman Lockyer has recently named a third, asterium.

Argon and helium have been captured, bottled, and examined pretty thoroughly as far as their physical proportions are concerned, but up to the present no chemical properties have yet been detected as belonging to them, so that although elements (*i.e.*, they are not compound) it seems paradoxical to speak of them as chemical elements—yet it is convenient and quite right that they should be so regarded.

You will all recollect that argon was discovered about three years ago by Lord Rayleigh and Professor Ramsay; it is a constituent of the atmosphere to the extent of about 1 per cent.; it was almost discovered by Cavendish about 100 years previously, and had the spectroscope been known in his time he certainly would have discovered it.

For some time it was thought that argon, although clearly not a compound body, might be a mixture, but the later experiments of Professors Ramsay and Norman Collie have practically proved that argon is not a mixture, but a simple substance, *i.e.*, an element, with a probable atomic weight of 40.

The name helium was given by Professors Lockyer and Frankland some thirty years ago to a supposed element in the sun, the existence of which was indicated by a yellow line (D_3, wave length 5,875·982) in the solar spectrum.

In his search for argon, in the gases given off by certain minerals when strongly heated, especially some containing uranium, yttrium, and thorium, Professor Ramsay obtained gases, which in the spectroscope gave certain characteristic lines, especially the remarkably brilliant yellow helium line, previously noticed by Professors Lockyer and Frankland in 1868 in the sun's chromosphere.

Ramsay isolated the gas characterised by the bright yellow line; there are also four other brilliant lines, viz., one each in the red, green, blue, and violet, but the yellow is the most important one. Its density was found to be about 2, *i.e.*, twice the density of hydrogen, the lightest gas known; in common with argon it is a monatomic gas, hence its atomic and molecular weights are identical, viz., about 4.

In his presidential address to the chemical section of the British Association at the Toronto meeting, Professor Ramsay points out that there should be an element between helium and argon with an atomic weight of 20, and if it consist of monatomic molecules, like argon and helium, it should have a density of 10; also that like helium and argon it should be practically inert and devoid of chemical properties. He and his assistant, Dr. Morris Travers, have been searching high and low for this element, but up the present have not succeeded in finding it.

In their pursuit after the supposed third gas Ramsay and Travers examined a vast number of minerals, and the gases given off by springs. They found that most minerals evolve gas when heated, consisting for the most part of hydrogen, mixed with carbon dioxide, and perhaps traces of carbon monoxide, and nitrogen; many gave helium as well, although in very small quantities. The helium like the nitrogen is probably in combination and not merely occluded or imprisoned.

Argon was only found in the mineral known as malacone, and in a specimen of meteoric iron.

The gas from the mineral springs at Cauterets in the Pyrenees was found to be rich in helium, but the unknown gas was sought for in vain. The helium found in the gases from springs may have been derived from minerals such as cleveite and monazite, through which the water has percolated.

Helium has not been detected in the atmosphere, and it is not likely to be found, for like hydrogen on account of

its low density and rapid motion, it would soon reach the borders of our atmosphere, and leave the earth for the sun or some heavenly body of greater mass than the earth; the sun has a mass 300,000 times that of the earth, and we know that both hydrogen and helium are abundantly present in its chromosphere—the moon is of small mass, and is without an atmosphere even of the heavier gases.

Helium has not yet been liquefied; its calculated boiling-point is below –264° C., or at least 20° lower than that of hydrogen, although it is twice the density of hydrogen; this is probably accounted for by its molecule being monatomic. [Helium has since been liquefied.]

Professors Ramsay and Collie found that the electric spark traverses argon and helium much more readily than it does oxygen or hydrogen, and that in fact it is not necessary to render a helium tube vacuous in order to obtain its spectrum; the spark passes readily at the ordinary atmospheric pressure.

It is well-known that hydrogen and carbon monoxide pass through an iron tube heated to redness. The passage of the latter gas through iron stoves is one of the causes of the deleterious effects of closed iron stoves, when used in-sufficiently-ventilated rooms. Hydrogen also passes through warmed platinum and palladium, but neither argon nor helium will do so, even at high temperatures; this is another proof of their inertness, for the hydrogen may pass through by the formation of an easily-decomposed compound, or by the gas being soluble in the metal.

Sir J. Norman Lockyer, in the Proceedings of the Royal Society for September 10, 1897, suggests the name asterium for the gas X detected in the spectra of the hottest stars and sun.

He further states that the lines of helium, asterium, and hydrogen are accompanied in the hottest stars by other lines, which may represent other new gases of a similar nature, or metals at a very high temperature.

The lines of hydrogen, helium, and asterium are found in the nebulæ with certain other bright lines of unknown origin; these probably exist at a low temperature. The unknown stellar lines are being sought for, and may be found to occur in gases of terrestrial origin.

LIQUEFACTION OF GASES.

Since Faraday's time no very great advance was made in the liquefaction of gases until 1878, when Cailletet, of Paris, and Pictet, of Geneva, almost simultaneously, but independently, were successful in liquefying oxygen, nitrogen, and other so-called permanent gases.

Cailletet submitted the cooled gas to very great pressure and then suddenly released it, when the remainder of the gas became sufficiently cooled by its rapid expansion to liquefy, and as the operation was conducted in glass tubes the formation of the mist and liquid was readily seen.

Pictet used a different method, viz., that known as the cascade or successive cycle process. For example, carbon dioxide can be liquefied, and this on evaporation yields a temperature of –80° C., or less, if its evaporation be increased by the use of an air-pump. The liquid carbon dioxide can thus be used to cool another and more volatile liquid, say ethylene, which on evaporation yields a reduction in temperature of –130°. Next the liquid ethylene is used for cooling a gas still more difficult to liquefy, say oxygen. The oxygen having been cooled down to –130° C. is readily condensed to the liquid condition by a pressure of 20 or 30 atmospheres. On releasing the pressure and allowing the oxygen to evaporate a reduction of –200° C. (when evaporating quietly at ordinary pressure it is –183°) is obtained. If the evaporation of the liquid oxygen be hastened by the use of an air-pump a temperature of –220°, or even –225°, may be produced.

Professor Dewar and others have since used processes in which Pictet's and Cailletet's methods are more or less combined.

Nitrogen can be liquefied and solidified, its freezing-point being $-214°$.

When air is solidified it appears to be a jelly-like substance, the liquid oxygen being held, as it were, in a spongy mass of nitrogen. By the use of glass vessels with double walls, with an insulating vacuum between them, Dewar has succeeded in restraining the evaporation of oxygen and similar liquefied gases to such an extent that they can be retained in open vessels for a comparatively long time, as when once the glass vessel is cooled down the liquid oxygen merely evaporates slowly from the surface; hence the manipulation is much simplified.

Hydrogen was found to be much more difficult to liquefy than the other gases, and was first brought about in 1894, its critical temperature being $-240°$. Dewar succeeded in solidifying oxygen by means of a jet of liquid hydrogen. On account of its rapid evaporation it cannot be collected and handled like oxygen.*

It is only within the last few years that fluorine has been obtained in the pure condition, simply because it destroyed the material of the apparatus in which it was prepared; but that difficulty has now been overcome—from the readiness with which fluorine, under ordinary conditions, acts upon glass and other substances. One of the early names given to it was Phthor, or the Destroyer.

Fluorine has hitherto resisted all attempts to liquefy it, but Professors Moissan and Dewar succeeded in April last by using liquid oxygen as the refrigorant at a little under the ordinary atmospheric pressure. It is a clear pale yellowish fluid, which does not attack glass, although its vapour does so with the greatest energy; at low temperature it can be stored and manipulated in glass vessels, and at such low temperatures its chemical activity is so much reduced that it has no action upon substances upon

* Since the above was written Professor Dewar has succeeded in liquefying large quantities of hydrogen.

which at ordinary temperature it acts with explosive violence. Cooled wood placed in it is untouched, but if a drop of the liquid fall on to the floor it bursts into flame.

Iron, silicon, boron, sulphur, and phosphorus, and other substances placed in liquid fluorine, after previous cooling in liquid oxygen, do not burst into flame as they do in the gaseous fluorine, but solid benzene and turpentine are decomposed with incandescence and explosive violence.

The boiling-point of liquid fluorine is –187°; its density is 1·14; it is soluble in all proportions in liquid air and liquid oxygen. It does not solidify at –210°, and has not yet been solidified. It has no absorption spectrum, and is not magnetic. At –190° it has no action on dry oxygen, water, or mercury, but reacts with incandescence on hydrogen.

By passing fluorine through liquid oxygen an explosive powder is produced; a hydrate of fluorine seems to be produced from the minute crystals of ice present in the liquid oxygen.

There are many other interesting points about fluorine still to be worked out.

At the Chemical Society, on November 4, Professor Dewar, after the paper upon liquid fluorine, gave another paper upon the liquefaction of air and the detection of impurities in it; even after careful filtration liquid air yields a deposit of solid carbon dioxide, and some organic matter; liquid air is always turbid unless perfectly pure.

He liquefied 80 litres of gas from a spring at Bath; the liquid was turbid, and a yellowish brown carbonaceous petroleum-like body was obtained from it; no trace of oxygen was found in the gas, but argon was present. Helium was found to be present in the original gas in the proportion of 1 in 1,000, and was left as a non-liquefiable residue.

It is found that at the very low temperature of liquid air that chemical action almost disappears, and that electric resistance also decreases, and at such rate that the curves indicate the total disappearance of the latter at what is termed the absolute zero, *i.e.*, –273° C. The tensile strength of many metals is much increased.

Certain substances also lose their colour, *e.g.*, flowers of sulphur becomes white at –50° C, and photographic plates lose their sensitiveness.

ARTIFICIAL DIAMONDS AND OTHER GEMS.

The preparation of artificial gems has long had an attraction for many chemists, and the preparation of artificial diamonds (imitation diamonds are easily made out of glass or paste) is now an accomplished fact, but at present they have only been made of a very small size, and are valueless as gems. It may, however, be possible to make larger ones in course of time, but at present they have all been of microscopic size.

But as diamond dust is very expensive, the smaller gems will have a considerable market value if they can be made cheaply enough.

It would take too long to describe all the different methods employed to prepare artificial diamonds since the first attempts were made by Wilson in 1850. Hannay, in 1880, claimed to have made diamonds by submitting hydrocarbons at a very great heat, in strong steel cylinders, to the action of metals like lithium and magnesium.

About the same time Mactear also states that he had obtained them ; clear, transparent, and with the form and refractive power of the natural diamond, but small in size.

Prof. Moissan, in 1893, prepared artificial diamonds by dissolving pure charcoal made from sugar in molten iron in the electric furnace, and then suddenly cooling the carburised iron in lead ; the iron and impurities were removed by acids, and minute crystals of diamond left.

Other observers have confirmed Prof. Moissan's results.

Carbon can be converted into a gas, and if the carbon could be maintained in the gaseous form and submitted to a high pressure for a sufficient length of time, we might obtain it in a liquid condition, and from that it might be possible to set free the solid carbon in a transparent condition, but, although the necessary temperature and pressure can be obtained separately it may not be easy to combine the two conditions.

Still another method for producing artificial diamonds has been described by Dr. Q. Majorana before the Roman Academy. He alleges that when carbon heated by the electric arc is submitted to a pressure of 5,000 atmospheres generated by an explosive compound in a confined space, that graphite and amorphous carbon are formed, together with minute crystals of diamond.

Minute diamonds are found in the residues left by cast steel of various kinds when treated with nitric, hydrofluoric, and sulphuric acids. Unhammered steel yielded iron carbides, and several modifications of carbon, one of which occurs crystallised in octohedra.

Rolled steel also yielded fragments of true diamonds. The very minute fragments of diamonds were only visible under magnifying powers of from 2,000 to 3,000 diameters, and they were apparently attacked by strong oxidising agents. Out of fifty varieties of steel examined by Leon Franck all except a few yielded diamonds.

M. Rossel also obtained diamonds from steel, the largest being ·5 mm. in diameter.

Artificial rubies have now been made for some years, but of small size and not fit for jewellery; now, however, they are in the market up to three dwts. in weight, and possessing the colour, hardness, specific gravity, composition and beauty of true rubies, but are distinguished from true rubies by not containing fluid cavities.

The former methods employed for making these gems were difficult, slow, and expensive, but they can now be prepared by a simpler process, viz., by merely fusing alumina, mixed with a chromium salt to impart the red colour, in the electric furnace.

ALUMINIUM.

Aluminium, which was, I think, first publicly shown at the Paris Exhibition of 1855, and described as the "silver from clay," is now being manufactured on a large scale at the Falls of Foyers, and the output is equal to and perhaps greater than that of any other works—rendered possible by the use of the Falls for generating electricity at a cheap rate.

Until within quite recent years aluminium remained almost a chemical curiosity. It is true that years ago it was used for making small ornamental articles, and for making an alloy with copper (aluminium bronze), but now that the chemistry of its preparation is reduced to the simple process of deoxidation in the electric furnace, it can be obtained in a pure form at a very cheap rate.

The chief advantages of aluminium are its lightness or low specific gravity, the readiness with which it forms most valuable alloys, and its highly electro-positive character.

Aluminium is particularly adapted for culinary utensils on account of its lightness, freedom from corrosion, and great thermal conductivity. It is also used in place of the expensive and heavy Solenhofen stone in "Lithography." The stone requires a heavy and powerful machine; the thin plates of aluminium do not, and, further, they can be curved round cylinders and the "lithograph" can be inserted with the type, and be printed from at the same rate as the letter-press.

Aluminium is not only being used for army equipments, but also for the construction of passenger railway carriages. In France a train is being built in which all the parts usually made of brass, copper, or iron (except the axles, wheels, springs, brake-beams, and couplings) are of aluminium,

the decrease in weight being about $1\frac{1}{2}$ tons, or on an ordinary train of twenty carriages a reduction of 30 tons. It has still to be seen whether aluminium will bear the wear and tear of railway work. It has not, perhaps, made such headway in boat-building as was anticipated, on account of its corrosion by sea water.

DIFFUSION OF METALS.

You know that if a cylinder, of a light gas like hydrogen, be placed with its open mouth against the mouth of a cylinder containing a heavy gas, like carbon dioxide, even if the heavy gas be in the lower cylinder, that after a short time it will be found that the heavy gas has ascended against the force of gravity into the upper cylinder, and that the light hydrogen has found its way down, and is equally intermingled with the heavy carbon dioxide—this is known as the diffusion of gases; the speed of diffusion of gases is a regular one, and it takes place at a rate inversely proportional to the square root of the density of the gases; so also with miscible liquids, if you place a light liquid upon a heavy one, *e.g.*, water upon a solution of copper sulphate, you will see after a time that the heavy blue liquid gradually rises against gravity, and spreads through the colourless water. So, too, Prof. Roberts-Austen has found, that if a cylinder of lead with a gold base be allowed to stand at a temperature of boiling water, that in the course of time a little of the heavy gold has diffused upwards through the lead. The gold diffuses still more rapidly at temperatures from 100° up to 150°, and, as might be expected, still more rapidly in melted lead at 550°; the diffusion can then be detected in a few days. Platinum does not diffuse so rapidly as gold; its molecules are therefore probably more complex.

I do not know that any practical application has yet been made of this fact, and some may accordingly ask what is the use of the experiment? But many of the most valuable inventions of modern times have arisen from what many regard as useless knowledge.

Whether it is likely to be useful or not, it is a most wonderful thing to find one metal travelling through another solid metal, just as gases diffuse through gases, and liquids through liquids—the motion is slower, it is true, but it exists, and it is none the less marvellous. The wonder is that the apparently rigid, solid, metallic molecules undergo a motion of mechanical translation at all, *i.e.*, as distinguished from a vibratory motion.

We are all well acquainted with the reverse of the above, for when two metals are melted together and allowed to cool slowly they often tend to separate. This is much more easily accounted for, since both metals have been in a fluid and mobile condition and are free to rearrange themselves, *i.e.*, the attraction between the molecules of a given metal is greater than that between the molecules of certain dissimilar metals.

ACETYLENE.

Two or three years ago it was only prepared in quite small quantities for experimental purposes, and was only known to chemists. It occurs in small quantity in coal gas, and is one of the most powerful illuminants present in it.

Now, however, thanks to cheap electricity, a compound of calcium and carbon, known as calcium carbide, is largely manufactured. On the addition of water to this material decomposition takes place, and acetylene is evolved.

It is true that acetylene is liable to explode, but only when it is stored under pressure. So long as the pressure is not much above that of the atmosphere, it appears to be safe enough; it must not be subjected to either rapid expansion or rapid condensation. In the liquid form it is not so safe; but, if properly handled, it should be a safe and an extremely useful illuminant for country and other places where coal gas or electricity is not obtainable.

Acetylene is also of great interest from a purely scientific point of view, as being the first and simplest synthesised compounds of carbon and hydrogen. From it, as a starting-point, other substances like alcohol, as well as complex

organic compounds, can be built up. Whether its cheapness will be taken advantage of for such purposes is at present doubtful.

A solution of acetylene in acetone appears to be less liable to explode than liquid acetylene; and, further, for the same unit of pressure on the cylinder, a larger volume of acetylene can be stored, *i.e.*, a solution in acetone contains more acetylene per unit of pressure than one of liquid acetylene.

There is no advantage in using liquid acetylene for transport, for 1 kilogramme (2·2 lb.) of calcium carbide only occupies the volume of ·45 litre, and yields ·3 cubic metre of acetylene, which, when liquefied, occupies twice the volume of the carbide. To light a railway carriage with 200-candle power for ten hours requires about 15 cubic metres of coal gas, about 8 of oil gas, but only 1·5 cubic metres of acetylene.

ARTIFICIAL INDIGO.

Alizarin, the bright red dye from madder, has now been made artificially from anthracene (formerly a waste product from coal tar) for some years, and it has practically superseded the use of madder for dyeing Turkey red, at a saving to English calico printers and dyers of, perhaps, £2,000,000 or £3,000,000 per annum.

Various methods for making indigo artificially have also been worked out, and although they are successful enough as laboratory experiments, they have not hitherto been successful from a commercial point of view, because the synthesised product costs more than the natural indigo. Lately, however, the Badische Anilin und Soda Fabrik have offered in the market an indigo which is said to be a coal-tar derivative. It is admitted to be a better dye, but the price is higher than that for the best natural indigo.

No details are given as to the method of manufacture; but, if it really be an artificial product, we may in time expect it to be sold at a lower rate than natural indigo, when indigo-planting may become a thing of the past, just

as madder-growing has become unprofitable, and, therefore, practically extinct. In the absence of any description of the reactions by which it is made, the report, I think, requires confirmation.

TRANSPARENCY OF THE CHEMICAL ELEMENTS TO THE RONTGEN RAYS.

Röntgen found that the rays from a Crooke's tube passed freely through black card-board, which is impervious not only to ordinary luminous and thermal rays, but also to the other invisible rays beyond the violet end of the spectrum, which are so active in producing fluorescence and photographic effects.

These invisible (X) rays passed freely through the opaque card-board and produced luminous effects upon screens coated with fluorescent substances, and, further, photographs could be taken by their aid on ordinary plates; afterwards it was found that they would go through many other substances, including sheets of metallic aluminium, and that they were not deflected by a magnet. They also dis-electrify an electrified body, and can neither be reflected nor refracted.

Although a perfect deluge of papers and scientific literature upon the X and other rays has appeared within the last two years, and an enormous number of people are experimenting upon these rays—there are even special Röntgen Ray Societies—yet I do not intend to go into the general subject, as it belongs to the domain of physics rather than chemistry—but as one of the most striking properties of the rays is that they pass through plates of a large number of metals, and still retain their chemical action upon salts of silver, and are capable of producing photographic effects, they are of interest from a chemical point of view.

The great interest and popularity which this subject so suddenly acquired was undoubtedly largely due to the fact that the flesh is more transparent to them than the bones of the skeleton; hence it is easy to see the outlines of the

bones as shadows by means of suitable fluorescent screens, and to take photographs of them or of solid foreign substances lodged in the body, such as bullets, or coins, which have been accidentally swallowed. Such photographs are now familiar to most of us; further, they have proved of use in surgery, since by their means the positions of foreign metallic bodies have been located, and the nature of certain injuries to the bones have been rendered more or less visible.

These X rays are by no means the only invisible rays known; there are several other kinds, viz., the ultra violet, the infra red, the Hertzian waves, the kathode, the Lenard, the Weidemann, the Becquerel, and other rays. All of these, except perhaps the infra red and Hertzian, produce photographic effects, and the kathode, the Lenard, Weidemann, Becquerel, and X rays pass through sheets of metallic aluminium.

The X rays do not bring about the combination of hydrogen and chlorine, but the ultra violet and Becquerel rays do.

It appears to be quite clear that the origin of the X rays is at the surface of the object upon which the kathode rays impinge, *i.e.*, the metallic reflector or the walls of the bulb.

One of the most recent and valuable accounts of the physical properties of the Röntgen rays is that given by Sir G. G. Stokes, Bart., F.R.S., before the Manchester Literary and Philosophical Society (the Wilde lecture, 2nd July, 1897), wherein he suggests that they may consist of innumerable solitary transverse waves. Others, however, contend that they are waves of but very short length.

Another use of the X rays to chemists has been shown by Messrs. Heycock and Neville. Gold forms a solid alloy with sodium; if slices, about 12 mm., or about ½ inch, thick of these opaque substances be examined by the X rays, the individual crystals of gold alloy are clearly seen, as the metallic sodium allows the X rays to pass through; hence photographs can be obtained of the crystals of the gold and sodium alloy in black upon a light ground.

They found by means of the X rays that the otherwise perfectly opaque alloy had an internal structure similar to that of a saline solution from which crystals had separated, the details being quite visible to the naked eye. They also hope to obtain similar results with aluminium alloys, since it is a metal also transparent to the X rays.

It is said that glass bulbs tinged with didymium chloride give a red instead of a green phosphorescence, and yield rays of twice the intensity of those from Crooke's tubes made of ordinary glass; hence the chemical composition of the glass is a factor in their formation or transmission.

There appears to be a very close relationship between the atomic weights of the elements and their permeability to the X rays.

Lithium, with an atomic weight of 7, is more transparent to them than sodium with an atomic weight of 23, and sodium is in turn more permeable to them than potassium with an atomic weight of 39. It has been found that a plate of lithium must be ten times as thick to produce the same amount of absorption as a plate of sodium. Hence the chemist may use this property in determining doubtful atomic weights.

C. Doelter finds that phenacite (beryllium silicate) is always perfectly transparent; and that olivine, zoisite, and sphene are, like calcite, almost opaque, and vesuvianite is only slightly less so.

Diopside, hiddenite, and topaz are semi-transparent. The diamond, sapphire, and ruby, both natural and artificial, are almost transparent, but paste imitations are opaque, and they are accordingly easily recognised by means of these rays. In fact, all gems, except garnets and zircons, contain elements of low atomic weight, and they are, therefore, more or less transparent to the X rays, which thus afford assistance in recognising them.

Doelter also finds that minerals with a greater density than 5 seem to be opaque to the rays.

Sulphur and arsenic compounds are the most opaque; boron and aluminium compounds are, as a rule, amongst the most transparent. Boric anhydride is even more transparent than the diamond.

He has framed a scale of transparency for minerals:—1, Diamond; 2, Corundum; 3, Talc; 4, Quartz; 5, Rock-salt; 6, Calcite; 7, Cerussite; 8, Realgar, which is quite opaque.

Crystals only show slight differences when viewed in various directions.

COLOUR PHOTOGRAPHY.

A great deal of interest is taken in this subject, and repeated statements have been made during the last year or two that success had at last been obtained; but up to the present no one has succeeeed in taking and fixing photographs in their natural colours, and on a single plate, or by a single print. Mr. Ives takes three transparencies from the same subject—one through an orange, one through a green, and one through a blue screen;—each is then illuminated by the corresponding light, and the three images superimposed, when a picture is presented in its natural colours.

Dr. Joly, of Dublin, reproduces the colour by a single negative by means of closely ruled red, blue, and green coloured lines on revolving screens; but the colours are only seen when the viewing screen is used. Another method is to use coloured transparent inks (printed from three negatives, taken by red, blue, and green lights respectively), instead of coloured films.

Becquerel found, fifty years ago, that if a plate be chloridised instead of iodised, and then exposed to white light, it acquired a violet tint, and that in this condition, on exposure to the solar spectrum, all the colours were reproduced, but unfortunately they cannot be fixed.

Lippman has found that by reflection from a film of mercury at the back of the negative he can obtain stationary

waves on the film, and that on development the silver is deposited between the nodes; viewed in the usual way, they are apparently ordinary negatives, but viewed at the requisite angle such plates exhibit the natural tints.

Hence the production of nature-coloured photographs is still a subject for investigation, for what is generally understood by the term has not yet been attained.

AGRICULTURAL CHEMISTRY AND SOME CHEMICAL EFFECTS OF BACTERIA.

The application of chemistry to agriculture has had a most marked effect upon the productiveness of the soil. Without going into details, the cultivation of the sugar-beet may be referred to. The original beet only yielded 2 or 3 per cent. of sugar, but now, by careful selection, cultivation, and treatment of the juice, beets grown in Germany yield 10, and even 15 to 18 per cent. of sugar. The latter is about equal to that from the sugar-cane. It is interesting to note that the amount of sugar yielded by the beet stands in close relation to the amount of potassium salts present. Beet-sugar is said to be now cheaper in Germany than flour.

Bacteria seem also to take a very important part in operations which have been considered as due solely to chemical action.

In the curing of tobacco leaf, it appears to be a well-recognised fact that the presence of certain bacteria is necessary for the preparation of leaf of high quality, and some manufacturers sprinkle the leaf with pure cultures of the requisite bacteria. The chemical changes which take place in the manufacture of white-lead by the Dutch process are also said to be due in part to bacteria, but this, I think, requires confirmation.

In the manufacture of liquid glue, of wines, beer, etc., and the ripening of cheese and butter, the products are due to the presence of certain bacteria, and in many cases the desired result, flavour, odour, etc., can be obtained and controlled by inoculation. By fermenting beer with wine

yeasts, beverages possessing the nutritious properties of beer wort, with characters similar to wine, can be obtained.

The modern brewer uses pure cultivations of yeast, so as to avoid the formation of undesirable products, and to always ensure the production of beers of uniform quality, taste, and odour.

Another example of valuable chemical processes brought about by low organisms is Wehmer's discovery that the mould *Citromyces* will convert sugar to the extent of 50 per cent. of its weight into citric acid.

It might be said that these questions are not chemical ones, but after all the products are truly and undoubted chemical ones, though vital processes have been more or less intimately connected in their formation.

A change appears to be coming over the views held in regard to fermentation. The production of alcohol by the yeast plant has been generally regarded, since the Liebig-Pasteur controversy, as due to the vital processes of the yeast plant, but recently it has been stated (by Buchner) to be probably of a secondary nature, and to be due to the excretion of a ferment by the yeast organisms, which can be separated by means of great pressure; this extract from the yeast, termed zymase (an enzyme), like the living yeast organisms, is said to cause the fermentation of sugar. This, however, requires confirmation; it is undoubtedly well worth further investigation.

Wroblewski claims that he has isolated the active portion of diastase (the greater part was found to be a carbohydrate which yielded arabinose when boiled with acids), and found that it has the properties of a proteid body. Although it has for some time been regarded as a proteid, this is the first experimental proof of its being one.

It appears to be now more or less well established that the formation of soil from rocks of various kinds is not entirely due to the action of frost, water, carbon dioxide, and the accumulation of dead organic matter; but that the

disintegration of the mineral matter is also in part brought about by the action of microscopic organisms and ferments.

It would appear that certain of the nitrifying organisms (bacteria) obtain their nitrogen from the air and from the traces of ammonia and other nitrogenous compounds present in it—these nitrifying organisms are of the greatest importance in agriculture, since through their agency higher forms of plant-life are supplied with suitable nitrogenous food. Roughly, these may be divided, first, into organisms which form ammonia or ammonium carbonate, from albumenous substances, which probably pass through the intermediate condition of amides ; second, into those which convert ammonium carbonate into nitrous acid ; and third, those which oxidise nitrous to nitric acid with rise of temperature, the salts of the last being the most useful condition of nitrogen as a plant-food, although plants also absorb nitrogen in other forms.

All these changes of course usually proceed simultaneously in cultivated soil.

Laboratory experiments show that not only do bacteria oxidise the carbon to carbon dioxide, and the nitrogen to nitrous acid, and this in turn to nitric acid, but that they also (B. mycoides) oxidise sulphur into sulphuric acid.

The oxidation of free nitrogen is brought about in at least two ways : on the rootlets of certain plants, especially amongst leguminous ones, nodules are found containing large numbers of bacteria, accompained by accumulations of nitrogen, apparently much greater than could have been removed from the soil or from manures in the ordinary way, and experiments seem to show that these accumulations are due to the bacteria of the nodules oxidising and assimilating atmospheric nitrogen.

Other organisms are also known which oxidise free nitrogen, but which do not give rise to nodules, so that cereals and other plants, which do not form nodules on their rootlets, also have supplies of accumulated oxidised nitrogen to draw

upon, and this accounts for the advantage of allowing fields to lie fallow or in grass.

Bacteria do not appear to require carbonaceous food beyond carbonates, and preferably bi-carbonates. For their nitrogenous food, nitrogen, ammonia, nitrites and nitrates, seem to be sufficient.

Bacteria can bring about the requisite chemical changes in the dark, but green plants can only build up chemical compounds from carbon dioxide and water in the presence of light.

The nitrogen oxides formed by electric discharges and other means in the atmosphere, and carried down by rain, are also of great importance and value. A large amount of the nitrous and nitric acids, nitrites and nitrates, present in the soil are carried off by drainage, since they are all very soluble in water.

The nitric acid in living plants is not carried off by water, but is held in some way at present unknown. From a dead plant it is readily extracted by water.

There are also other ferments present in soils which reduce or destroy nitric acid, whereby it is lost; these are known as denitrifying ferments. Fortunately these inimical ones are usually present in smaller numbers than the friendly ones; the conditions favourable to these are also well worthy of the closest investigation.

Nitrifying organisms are widely distributed; they are found even on the bare mountain tops and in the deep-seated chalk obtained from the deepest artesian wells.

The culture of the useful nitrifying organisms has become a matter of business, and, under the name of nitragin, they are put up in bottles for the market. Different cultivations or varieties can be purchased to suit the particular soil or kind of crop which it is desired to inoculate, but they do not always appear to be successful.

Closely connected with the foregoing is the occurrence of nitrogen and other gases in rocks, *i.e.*, as distinguished from

soils. Lately a great deal of attention has been given to this subject; but it is by no means a new one, for Professor Delesse published in the Ann. des Mines in 1860 a long investigation upon the occurrence of nitrogen and organic matters in rocks, entitled "De l'azóte et des matières organiques dans l'écorce terrestre."

In this he gives the amount of nitrogen obtained from 104 varieties of crystalline and sedimentary rocks from different parts of Europe, including various calcareous rocks, grits, sandstones, marl, and alluvial soils.

They all yielded nitrogen; most of them gave ammoniacal, but others acid, products on distillation. Some gave acid products at first, followed by alkaline ones, and a tarry odour. The nitrogen was, doubtless in many cases, present as organic compounds.

Some years ago, 1873–4, I examined a large number of minerals and rocks for "organic matter," and found that rock-crystal, amethyst, topaz, and many other minerals gave off gases and ammoniacal empyreumatic distillates, but the investigation had to be laid aside, and the results have not yet been published.

Hugo Erdmann (Ber., 1896, 29) has also found that a number of minerals which occur in ancient igneous rocks evolve ammonia when warmed with pure soda solution, and he has estimated the amounts; thus a mineral resembling polycrase gave ·028 per cent. of nitrogen evolved as ammonia. Another mineral resembling euxenite contains ·005 per cent. of nitrogen. He states that many other minerals from the north of Europe also contain nitrogen, such as ytterspar, euxenite, fergusonite, gadolinite, and æschynite. Professors Ramsay and Tilden, working independently, however, did not find nitrogen in most of the minerals examined by them.

It was known that hydrocarbons, carbon monoxide, carbon dioxide (in both the liquid and gaseous states), nitrogen, and other gases occurred in rocks, but they found

hydrogen also present in a great many different varieties of rocks, and in comparatively large proportions to the volume of other gases; no free oxygen was found, hence it may be that the hydrogen was originally present as water at a high temperature, and that the oxygen has been removed by metallic or other oxidisable substances. It may be that the nascent hydrogen combines in part with nitrogen to form ammonia, which would account for the presence of ammonia in minerals and igneous rocks.

The presence of methane and other hydrocarbons, and of petroleum in rocks, is thought to show that in the lower part of the earth's crust there exist metallic masses and compounds of metals with carbon; for such when in contact with water at a high temperature would give rise to metallic oxides, and to gaseous and liquid hydrocarbons, as suggested by Mendeléeff. This is also supported by Moissan's recent researches on the metallic carbides, and we have the now familiar method of making an illuminating gas (acetylene) by adding water to one of them, viz., calcium carbide.

There are many other matters of more or less general interest in chemistry which might have been touched upon, did time permit, such as the recent advances in our knowledge of Solar and Stellar chemistry; the occurrence and distribution of the rare elements, and especially of the rare metals, because so many of them are now entering into daily use—as in the case of other commodities the demand reacts upon the supply—*e.g.*, substances like thoria, a few years ago only obtainable by the grain weight, are now produced by the ton; also upon cellulose and the manufacture from it of the so-called artificial silk, but better termed imitation silk, as it is of a totally different composition to true silk.

In conclusion, I sincerely trust that our non-resident members will have no cause to regret their visit to Sydney, in this the least pleasant part of the year, and that the Session will be a profitable one to all concerned, and especially that the work of the meeting will distinctly mark an advancement of science in Australasia.

APPENDIX.

The following delegates attended the International Scientific Catalogue Conference :—

Austria.—Prof. Ernst Mach (Mitglied der Kaiserlichen Akademie der Wissenschaften, Vienna) ; Prof. Edmund Weiss (Mitglied der Kaiserlichen Akademie der Wissenschaften, Vienna).

Belgium.—M. H. La Fontaine (Membre de l'Institut International de Bibliographie, Brussels) ; M. Paul Otlet (Membre de l'Institut International de Bibliographie) ; M. de Wulf (Membre de l'Institut International Bibliographie).

Denmark.—Prof. Christiansen (Universitet, Copenhagen).

France.—Prof. G. Darboux (Membre de l'Institut de France) ; Dr. J. Deniker (Bibliothécaire, Muséum d'Histoire Naturelle, Paris).

Germany.—Prof. Walther Dyck (Mitglied der K. Bay. Akad. der Wiss. zu München) ; Prof. Dziatzko (Direktor der Universitäts Bibliothek, Göttingen) ; Prof. Van't Hoff (Mitglied der K. P. Akademie der Wissenschaften zu Berlin) ; Prof. Möbius (Mitglied der K. P. Akademie der Wissenschaften zu Berlin) ; Prof. Schwalbe (Direktor, Berlin).

Greece.—M. Avierinos M. Averoff (Greek Consul at Edinburgh).

Hungary.—Dr. Theodore Duka (Membre Académie Hongroise des Sciences, Buda-Pesth) ; Prof. August Heller (Librarian, Ungarische Akademie, Buda-Pesth).

Italy.—General Annibale Ferrero (Italian Ambassador in London).

Japan.—Assistant Professor Hantaro Nagaoka (University, Tokio) ; Assistant Professor Gakutaro Osawa (Medical College, Tokio).

Mexico.—Señor Don Francisco del Paso y Troncoso.

Netherlands.—Prof. D. J. Korteweg (Universiteit, Amsterdam).

Norway.—De Jörgen Brunchorst (Secretary, Bergen Museum).

Sweden.—Dr. E. W. Dahlgren (Librarian, Kongl. Svenska Vetenskaps Akademie, Stockholm).

Switzerland.—M. C. D. Bourcart (Swiss Minister in London) ; Prof. Dr. F. A. Forel (Président du Comité Central de la Société Helévtique des Sciences Naturelles).

United Kingdom.—

Representing the Government : Right Hon. Sir John E. Gorst, Q.C., M.P. (Vice-President of the Committee of Council on Education).

Representing the Royal Society of London : Prof. Michael Foster (Sec. R.S.) ; Prof. H. E. Armstrong, F.R.S. ; Mr. J. Norman Lockyer, C.B., F.R.S. ; Dr. Ludwig Mond, F.R.S. ; Prof. A. W. Rücker, F.R.S.

United States.—Dr. John S. Billings (U.S. Army) ; Prof. Simon Newcomb, For. Mem. R.S. (U.S. Nautical Almanac Office).

Canada.—The Hon. Sir Donald A. Smith, G.C.M.G. (High Commissioner for Canada).

Cape Colony.—Roland Trimen, Esq., F.R.S. ; Dr. David Gill, F.R.S.

India.—Lieut.-General Richard Strachey, R.E., F.R.S.
Natal.—Walter Peace, Esq., C.M.G. (the Agent-General for Natal).
New South Wales.—Prof. Liversidge, F.R.S.
New Zealand.—The Hon. W. P. Reeves (Agent-General for New Zealand).
Queensland.—Chas. S. Dicken, Esq., C.M.G. (Acting Agent-General for Queensland).

The following are some of the resolutions agreed to:—

That each delegate shall have a vote in deciding all questions brought before the Conference.

That it is desirable to compile and publish by means of some international organisation a complete catalogue of scientific literature, arranged according both to subject-matter and to authors' names.

That in preparing such a catalogue, regard shall, in the first instance, be had to the requirements of scientific investigators, to the end that these may, by means of the catalogue, find out most easily what has been published concerning any particular subject of enquiry.

That the administration of such a catalogue be entrusted to a representative body, hereinafter called the International Council, the members of which shall be chosen as hereinafter provided.

That the final editing and the publication of the catalogue be entrusted to an organisation, hereinafter called the Central International Bureau, under the direction of the International Council.

16. That any country which shall declare its willingness to undertake the task shall be entrusted with the duty of collecting, provisionally classifying, and transmitting to the Central Bureau, in accordance with rules laid down by the International Council, all the entries belonging to the scientific literature of that country.

That in indexing according to subject-matter, regard shall be had, not only to the title (of a paper or a book), but also to the nature of the contents.

That the catalogue shall comprise all published original contributions to the branches of science hereinafter mentioned, whether appearing in periodicals or in the publications of societies, or as independent pamphlets, memoirs, or books.

That in each country the system of collecting and preparing material for the catalogue shall be subject to the approval of the International Council.

That in judging whether a publication is to be considered as a contribution to science suitable for entry in the catalogue, regard shall be had to its contents, irrespective of the channel through which it is published.

That the Central Bureau shall issue the catalogue in the form of "slips" or "cards," the details of the cards to be hereinafter determined, and that the issue take place as promptly as possible. Cards corresponding to any one or more branches of science, or to sections of such sciences, shall be supplied separately at the discretion of the Central Bureau.

That the Central Bureau shall also issue the catalogue in book form from time to time, the entries being classified according to the rules to be hereinafter determined.

That the issue in the book form shall be in parts corresponding to the several branches of science, the several parts being supplied separately, at the discretion and under the direction of the Central Bureau.

That a contribution to science for the purposes of the catalogue be considered to mean a contribution to the mathematical, physical, or natural sciences, such as, for example, mathematics, astronomy, physics, chemistry, mineralogy, geology, botany, mathematical and physical geography, zoology, anatomy, physiology, general and experimental pathology, experimental psychology and anthropology, to the exclusion of what are sometimes called the applied sciences—the limits of the several sciences to be determined hereafter.

31. That the Royal Society be requested to form a committee to study all questions relating to the catalogue referred to it by the Conference, or remaining undecided at the close of the present sittings of the Conference, and to report thereon to the Governments concerned.

Since it is probable that, if organisations be established in accordance with Resolution 16, the Guarantee Fund required for the Central Bureau can be provided by voluntary subscriptions in various countries, this Conference does not think it necessary at present to appeal to any of the Governments represented at the Conference for financial aid to the Central Bureau.

The Conference being unable to accept any of the systems of classification recently proposed, remits the study of classifications to the committee of organisation.

The Belgian delegates expressly desired that it be placed on record that they abstained from voting on this resolution.

That English be the language of the two catalogues, authors' names and titles being given only in the original languages, except when these belong to a category to be determined by the International Council.

That it be left to the Committee (of the Royal Society) to suggest such details as will render the catalogues of the greatest possible use to those unfamiliar with English.

That it is desirable that the Royal Society should be informed, at a date not later than January 1st, 1898, what steps (if any) are being taken, or are likely to be taken, in the countries whose Governments are represented at the Conference, towards establishing organisations for the purpose of securing the end in view of Resolution 16.

That the delegates, in reporting to their respective Governments the proceedings of the Conference, should call immediate attention to Resolutions 16 and 31.

That January 1st, 1900, be fixed as the date of the beginning of the catalogue.

That the Royal Society be requested to undertake the editing, publication, and distribution of a verbatim report of the proceedings of the Conference.

REPORTS OF RESEARCH COMMITTEES.

REPORTS OF RESEARCH COMMITTEES.

No. 1.—REPORT OF SEISMOLOGICAL COMMITTEE.

Members: Mr. A. B. Biggs (Launceston), Mr. R. J. L. Ellery (Melbourne), Sir James Hector (Wellington), Mr. H. C. Russell (Sydney), Sir C. Todd (Adelaide), Mr. G. Hogben, Secretary (Timaru, N.Z.)

It is to be regretted that up to the present the observations of earthquake phenomena in Australasia have been so fragmentary and of so varying a character.

The Committee would emphasise the remarks of the President of Section A, in reference to this matter, and also would call special attention to a circular issued by the Seismological Committee of the British Association, from which the following is an extract:—

"It has been established that the movements resulting from a large earthquake originating in any one portion of the globe can, with the aid of suitable instruments, be recorded at any other portion of the same; therefore, the Seismological Investigation Committee of the British Association are desirous of your co-operation in an endeavour to extend and systematize the observation of such disturbances. Similar instruments should be used at all stations. The one recommended by this Committee is simple to work, and furnishes results sufficiently accurate for the main objects in view. . . . . Its cost, including photographic material to last one year, packed for shipment, is about £50. . . . . In case an instrument be established at your observatory, we should ask that notes of disturbances having an earthquake character be sent to us for analysis and comparison with the records from other stations. . . . . The first object we have in view is to determine the velocity with which motion is propagated round, or possibly *through*, our earth. To attain this, all that we require from a given station are the times at which various phases of motion are recorded; for which purpose, for the present at least, we consider an instrument, recording a single component of horizontal motion to be sufficient. Other results which may be obtained from the proposed observations are numerous.

"The foci of submarine disturbances, such, for example, as those which from time to time have interfered with telegraph cables, may possibly be determined, and new light thrown upon changes taking place in ocean-beds. The records throw light upon certain classes of disturbances now and then noted in magnetometers and other instruments susceptible to slight movements, whilst local changes of level, some of which may have a diurnal character, may, under certain conditions, become apparent." . . . .

To carry out these aims it is highly desirable that some of the instruments thus recommended should be set up at several places in Australasia. If not, the chain of observing stations round the world will be broken, and the value of all the records be rendered less by our neglect. It is obvious also, as is pointed out in a circular issued by the International Seismological Committee, that in every country it is a necessary supplement to the proposed work that all the local earthquakes should be observed as carefully and accurately as possible, in order that seismic origins may be found, and that a clear idea may be formed of the circumstances accompanying any earthquake occurring therein. Much of this latter work may be done without instruments, most easily at telegraph stations, but also by any private person who has the means of checking his times of observation with the standard time of the colony in which he lives. This has been done systematically in New Zealand since 1889, with the result that many of the origins are known, the velocities of propagation have been ascertained for many of the shocks, and in a few cases the probable depth of the centrum has been found. The Committee are recommending an addition to their number, so that there may be in every colony at least one person responsible for doing this part of the work.* A copy of the form used in New Zealand is annexed below.

The New Zealand Government, on the recommendation of Sir James Hector, has ordered two of the instruments approved by the British Association Committee, and this Committee would suggest that one of the instruments be placed under the charge of the secretary.*

The most considerable earthquake in Australasia since the date of our last report is that of the 10th May, 1897, which will form the subject of a separate investigation by the secretary. A preliminary examination of the facts points to a line of origin below the sea-bed not far from the coast of South Australia, opposite Beachport and Kingston, the movement being probably a more or less deep fault movement. Severe earthquakes also occurred in the Cook Strait area of New Zealand on 21st Sept., 1897, and on 8th Dec., 1897. These are likewise still under examination.

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* See list of Committees of Investigation appointed, and recommendations agreed to, by the General Council, A.A.A.S., on 13th Jan., 1898.

EARTHQUAKE at ______________, N.Z. *Date of Shock* ______________ 189 .

[Please answer precisely any or all of the following questions.]

1. Time of beginning of shock. (*If possible, N.Z. mean time to nearest quarter or half minute.*)	
2. Whether clock was verified by N.Z. mean time.	
3. Apparent direction—*e.g.*, S.E. to N.W., then N.E. to S.W.	
4. Apparent duration of shock.	
5. Effects, *e.g.* :	
(*a*) Felt by persons in motion ; disturbance of movable objects, doors, windows, cracking of ceilings.	
(*b*) Felt generally by everyone ; disturbance of furniture and beds, ringing of some bells.	
(*c*) General awakening of those asleep ; general ringing of bells, oscillation of chandeliers, stopping of clocks ; visible disturbance of trees and shrubs. Some startled persons leave their dwellings.	
(*d*) Overthrow of movable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings.	
(*e*) Fall of chimneys, cracks in the walls of buildings.	
(*f*) Destructive damage.	
6. Remarks. (*e.g., previous or subsequent tremors ; spilling of liquids, with direction of overflow ; rumbling or other noise—state whether heard before, during, or after shock.*)	

N.B.—The N.Z. returns are valuable not only in themselves, but as part of a world-system of seismological observations, and your attention is called to the fact that the reliable character of the record depends upon the individual accuracy of each observer. No shock, however slight, should be omitted.

Signature of Observer ______________

Address ______________

Date ______________

These forms are issued to observers in books containing 12, 25, or 50 forms.—Sec. Seism. Comm.

Earthquake Shocks in New Zealand, 1894—Aug., 1897.

* Time verified : A=A.M. ; P=P.M.

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1894.						
Jan. 8	Opunake	9·20 P*	S. to N.	1 sec.	Slight	III.
,, 11	Wanganui	10·33 P*	S.W. to N.E.	7 secs.	Jerk and vibrations	III.
,, 13	Opunake	7·34 A*	S.E. to N.W.; then S. to N.	14 secs.	Sharp double shock; crockery rattled; pictures disturbed; moderate rumbling; continuous tremor for five minutes. Other shocks reported during day.	IV.
,, 21	Wanganui	9·26 P*	N.W. to S.E.	3 secs.	Loud rumbling	III.
,, 23	,,	7·15 P	S.W. to N.E.	3 secs.	Sharp jolts and vibrations	III.
Mar. 18	Wellington	6·40 P*	Vertical	6 secs.	Two sharp shocks at interval of 3 secs. Shutters rattled.	IV.
,, 20	Wanganui	10·20 P	S.W. to N.E.	1 sec.	Sharp jolt and a few vibrations, preceded by rather long and loud rumbling.	III.
,, 29	,,	9·12 P	S.W. to N.E.	5 secs.	Light vibrations; slight rumble	III.
,, 29	Opunake	12·2 P*	S.E. to N.W.	2 secs.	Slight	III.
April 2	Wanganui	1·44 A	S.W. to N.E.	10 secs.	Sharp vibrations; doors and windows rattled	IV.
,, 2	Blenheim	1·40 A*	N. to S.	4 secs.	Severe; clocks stopped; crockery broken	VI.
,, 2	Nelson	1·41 A*	W. to E.	A few seconds	Previous and subsequent tremors sharp	IV.
,, 2	Wellington	1·41 A*	....	Several seconds	Severe; a second shock reported 3·37 a.m.	IV+.
,, 2	Kaikoura	1·40 A*	S.W. to N.E.	30 secs.	Sharp; slight rumbling	IV.
,, 5	Wanganui	4·18 A	S.W. to N.E.	12 to 15 secs.	Moderate vibrations	III.
,, 7	,,	11.0 P	S.W. to N.E.	....	Slight. Felt by a person in motion	III to IV.
,, 14	,,	2·44 A	S.W. to N.E.	About 60 secs.	Rather sharp	IV.
,, 19	,,	2·25 A	S.W. to N.E.	20 secs.	Vibrations for fully 2 minutes. (Field)	III to IV.
,, 19	Opunaki	2·23 A*	W. to E. and S.E. to N.W.	10 secs.	Buildings creaked; suspended objects oscillated; very loud rumbling. Sharp double shock.	IV.
,, 19	Wanganui	3·7 A	S.W. to N.E.	About 30 secs.	Moderate vibrations	III.
,, 24	Queenstown	9·58 P* 11·29 P*	N. and S.	4 secs. 4 secs.	Sharp. Each shock preceded by rumbling	III.
May 8	Auckland	4·3 A*	E. to W.	15 secs.	Sharp; doors and windows rattled. No tremors or rumbling previous.	IV.
,, 8	,,	5·5 A*	E. to W.	5 secs.		
,, 8	,,	6·15 (about)	E. to W.	5 secs.	Slight	III.
,, 8	Thames	4 A	N. and S.	10 secs.	Sleepers awakened; doors, &c., rattled; rumbling	V to VI.
,, 8	Coromandel	4 A	S.E. to N.W.	....	Severe; doors, &c., severely shaken; door ajar opened wide.	V.

Earthquake Shocks in New Zealand—*continued.*

Date.		Place.	Time of Beginning of Shock– (N.Z. Mean Time.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1894.							
May	8	Coromandel..	4·56 A	S.E. to N.W.	....	And other shocks to 6·30 a.m. Sharp to slight; slight rumbling accompanying.	IV to III.
			5·30 A	S.E. to N.W.	....		
,,	8	Kuaotunu	4 A	....	....	Several sharp shocks between 4 and 7 a.m	IV.
,,	8	Te Aroha......	4 A	S.E. to N.W.	....	Slight	III.
,,	8	Whitianga and Tairua.	4 A	E. to W.	....	Several sharp shocks between 4 and 6 a.m.	III to IV.
,,	9	Coromandel ..	12·19 P*	S.E. to N.W.	15 secs.........	Building severely shaken	V.
,,	9	,, ..	9·35 P	S.E. to N.W.	....	Doors and windows severely shaken; also felt at Whangapoua and Thames.	IV to V.
,,	9	Kuaotunu ..	9·30 P	....	....	Sharp..........	IV.
			10 P				
,,	18	Wanganui	12·50 A	....	....	Rather smart	III.+
,,	21	Greymouth....	9·40 A.........	....	....	"Very slight," or "sharp".........................	III.
,,	21	Nelson	9·40 A	S. to N.	10 secs....	Slight	IV.
	21	Wellington	9·40 A	N.W. to S.E.	....	Old cracks opened, and plaster fell from ceiling and walls of Public Library; preceded by loud crash, causing people to rush out. Small shock reported at 4·30 a.m., accompanied by sharp explosion.	VI.
,,	21	New Plymouth	9·50 A	....	....	Things rattled	IV.
June	24	Wanganui	10·40 A	N.E. to S.W.	3 secs.........	Loud rumbling..	III.
July	2	Rotorua	4·51 A*	E. to W.	About 5 secs. each.	Rumbling with first shock; seven minor shocks intervening; sharp. Not felt at Taupo, Maketu, or Tauranga.	IV.
			9·20 A*				
			10·29 A*				
,,	6	Greymouth....	3·45 P	E. to W.	3 secs.........	Slight	III.
,,	10	Wanganui ...	5·30 A	N.E. to S.W.	10 secs.........	Sharp	III.
,,	10	Opunaki	5·21 A	E. to W. and S.E. to N.W.	2 secs.......	Sleepers awakened; oscillation of hanging articles. Tremor and rumbling in both shocks.	V.+
,,	10	,, ...	5·23 A	S. to N.	1 sec.		III.
,,	18	Wanganui	1·40 A	N.E. to S.W.	6 secs.........	Sharp	III.
Aug.	29	Hokitika	4·50 A	E. to W.	Several seconds	Slight	III.
,,	29	Culverden	4·51 A*	W. to E.	About 15 secs..	Sharp; office clock stopped; chimneys twisted; crockery smashed.	VI.
,,	2	Greymouth....	4·55 A*	N. to S.	2 to 3 secs....	"Rather sharp"	III.

Earthquake Shocks in New Zealand—*continued.*

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1894.						
Aug. 30	Culverden	7·9 P* / 7·52 P*	W. to E.	Each 2 or 3 secs.	Sharp	III. / III.
Sept. 9	Greymouth	2 22 P*	N. to S.	4 secs.	Sharp; tremors gradually increasing until a short sharp shock was felt.	III.
,, 16	Wellington	12·35 A*	N.E. to S.W.	2 secs.	Slight	III.
Oct. 2	Nelson	6·31 P*	N. to S.	3 secs.	Sharp	III.
,, 2	Blenheim	6·36 P*	N.W. to S.W.	2 secs.	Slight	III.
Nov. 23	Kaikoura	11·25 A*	S.E. to N.W.	1 to 2 secs.	Sharp sudden jerk; disturbance of movable objects	IV.
,, 25	Auckland	4·33 A*	E. and W. ?	15 to 20 secs.	One clock stopped; sudden abrupt shock; followed by two similar smaller shocks.	V.
Dec. 4	Bluff	6·40 A*	N.W. to S.W. (*sic*)	25 to 30 secs.	Sharp; preceding by rumble from N.W.	IV.+
,, 4	Invercargill	6·40 A*	N. to S.	15 to 20 secs.	Several clocks stopped; preceded by slight tremor.	VI.
,, 4	Dunedin	6·40 A*	W. to E.	10 secs.	Sharp	III.+
July 22	Bua, Fiji	About 5 A	...	...	Quaking and double shock	III.
Sept. 23	,,	About 5 A	S.W. to N.E.	A few secs. and 30 secs.	Two sharp shocks within five minutes; house shaken; things rattled. (Rev. J. Chapman, Wesleyan Mission).	IV.
1895.						
Jan. 12	Greymouth	7·10 P*	N.E. to S.W.	10 secs.	Sharp	III.
Feb. 20	Opunake	10·26 A*	E. to W.	1 sec.	Slight	III.
May 2	Kaikoura	11·4 P*	N.W. to S.E.	1 to 2 secs.	Very short and sharp	III.+
,, 27	Wellington	10·27 A*	E. to W.	20 secs.	Very marked and prolonged	IV.
,, 27	Bulls	10·25 A	N. to S.	20 secs.	Slight	III.
,, 27	Nelson	10·25	...	1 to 2 secs.	Slight	III.
,, 27	Wanganui	10·25*	N.E. to S.W.	10 secs.	Rattled glasses and globes	IV.
June 3	Blenheim	1·59·50 P*	N.W. to S.E.	2 secs.	Buildings shaken; severe rumbling; previous sharp tremors.	IV.+
,, 3	Wellington	2 P*	N. to S.	3 secs.	Slight	III.
,, 3	Nelson	2·1 P	S. to N.	About 10 secs.	Suspended objects swing	IV.
,, 3	Greymouth	2·5 P	N. to S.	...	Slight	III.
,, 8	,,	8·43 P*	E. to W.	5 secs.	Sharp	III.
July 12	Bulls	3·26 P*	E. and W.	...	Slight	III.
,, 27	Dunedin	7·16 A*	...	4 secs.	Rumbling before	III.
Aug. 4	,,	5·59 P*	N. to S.	5 secs.	Slight	III.

Earthquake Shocks in New Zealand—*continued.*

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1895. Aug. 4	Christchurch	5·58 P	E. and W. (or S.W. to N.E.)	....	Accompanied by loud rumbling; smart; cups on dresser swung from E. to W.; clock stopped on a south wall, another on a N.W. wall; loud rumbling before shock like cart, increasing to loud roar; two chimneys fell.	VI.
„ 4	Timaru	5·59½ P*	N. and S.	A few secs.	Noise preceded and accompanied	III.
4	Lyttelton	5·55 P	E. to W.	....	Three shocks; first light and accompanied by a distinct rumble; other two heavy.	III. to IV.
„ 17	Amberley	5·57 P	....	....	....	III.
„ 17	Waotu	6·26 P*	N. to S.	30 secs. or less.	Windows rattled	IV.
„ 17	Bulls	6·25 P*	N.E. to S.W.	40 secs.	Sharp	IV.
„ 17	Feilding	6·26 P*	W. to E., then S. to N.	60 secs.	Swinging lamp; water in bath moved; sharp	IV. +
17	Wanganui	6·26½ P*	N. to S.	40 secs.	Sharp; previous tremor; fire-bell rung; clocks stopped.	VI.
„ 17	Taupo	6·37 P*	N.E. to S.W.	3 secs.	Sharp	IV.
„ 17	„	6·40 P*	N.E. to S.W.	5 secs.	Very severe; nearly all the chimneys fell; crockery smashed; tables overturned; general panic; animals alarmed; tourists left; the shocks did not cease all night; twenty-seven shocks noted between 12·41½ a.m. and 3·54 a.m., eight "heavy" or "very heavy." Continued for days after ("not ceased," 4th September). The chief shock had an upward movement. Large cracks in the ground between Wairakei and Opepe, emitting cold water and fine white pumice; large landslips at Rotongaio; Tongariro, &c., all inactive for two or three days after.	VIII. +
„ 21	Wanganui	1·39 A	S.W. to N.E.	Nearly 1 min.	Rather loud rumble; doors and windows rattled	IV.
„ 21	Wellington	1·40 A	....	2 secs.	Slight	III.
„ 21	Bulls	1·30 A	N.E. to S.W.	30 secs.	Sharp	III. +
„ 21	Feilding	1·40 A*	....	....	Slight	III. −
„ 22	Wanganui	9·26 P	S.W. to N.E.	Nearly 1 min.	Low rumble, followed by gentle vibrations	III.
„ 24	„	0·10 A	S.W. to N.E.	1 min.	„ „ „	III.
„ 24	„	0·42 A	S.W. to N.E.	....	„ „ „	III.
„ 31	„	11·15 A	S.W. to N.E.	....	Rather loud explosion followed a few slight vibrations	III.

Earthquake Shocks in New Zealand—*continued.*

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1895. Aug. 31	Wanganui	About midnight	......	......	"Slight" or "sharp"; felt by many persons	III.
Sept. 2	,,	9·36 P	S.W. to N.E.	......	Rather loud rumble, sharp jolt, and a few vibrations	III.
,, 4	,,	8·27 A	S.W. to N.E.	......	Very loud rumble and sharp vibrations	IV.
,, 24	Opunake	6·32 A*	E. to W.	2 secs.	Slight rumbling and tremor, five or six seconds after a report, as of cannon. Other shocks, 24th September (1), 25th (1), 27th (1).	III.
,, 28	,,	9·20 A*	E. to W.	1 sec.	Slight tremor and rumbling (previous)	III.
,, 28	,,	1·27 P*	S.E. to N.W.	8 secs.	Very sharp double shock; building rocked and creaked, door swung, pictures moved; strong tremor and loud rumbling (previous). Also four shocks on 29th September, no details; also one on 30th.	IV.
,, 8	New Plymouth.	1·30 P*	N.E. to S.W.	10 secs.	Sharp; lamps swung for considerable time; no rumbling.	IV.
,, 29	Wanganui	About 1·15 P	S.W. to N.E.	......	Moderate rumble and sharp vibrations	III.
Oct. 1	Opunake	4·30 A	S.E. to N.W.	5 secs.	Building creaked and crockery rattled; considerable previous rumbling and tremor.	IV.
,,	,,	About A	......	1 sec.	Slight rumbling; slight shock	III.
,, 2	,,	About 9·20 P	E. to W.	3 or 4 secs.	Slight rumbling; sharp	III.+
,, 2	,,	10·29 P*	E. to W.	3 secs.	Sharp; building creaked; moderate rumbling (previous)	III.+
,, 3	New Plymouth.	About 12·45 A	W. to E.	Several secs.	Sharp. Several shocks (10 to 15?) since 28th September, reported by others, but not felt by observer.	III.+
,, 3	Opunake	12·38 A*	E. to W.	15 secs.	Very sharp; preceded by loud rumbling and tremor; hanging objects swung.	IV.
,, 3	,,	5·9 A*	E. to W.	5 secs.	Sharp; preceded by slight rumbling and tremor; buildings creaked.	III. to IV.
,, 3	,,	7·54 A*	......	1 sec.	Slight, with previous tremor	III.
,, 3	,,	12·20 P*	......	1 sec.	Slight, with previous tremor; other slight shocks reported.	III.
,, 3	,,	9·38 P*	E. to W.	2 secs.	Crockery rattled; one or two articles thrown down; loud and continued rumbling before and after shock, noise lasting about 1½ minutes; considerable tremor.	V. to VI-
,, 4	New Plymouth.	Between 2 & 4 P	N.E. to S.W.	......	Slight	III.—
,, 5	,,	9·40 P*	N.E. to S.W.	10 secs.	Sharp; windows cracked	IV.

Earthquake Shocks in New Zealand—*continued.*

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1895.						
Oct. 12	Opunake	9·47 A*	E. to W	2 secs.	Slight; previous slight rumbling	III.
" 12	"	11·52 A*	E. to W.	8 secs.	Sharp; suspended objects shaken; heavy previous rumbling and tremor.	IV.
" 12	New Plymouth.	11·54 A*	N.E. to S.W.	10 secs.	Sharp and sudden, with loud noise; one other shock reported at 4 a.m.	III.+
" 17	Opunake	2·46 P*	E. to W.	2 secs.	Building slightly creaked	III.+
" 17	"	4·25 P*	E. to W.	1 sec.	Slight	III.
[Between 2nd and 13th October three shocks reported at Wanganui; observer absent in Wellington.]						
" 25	New Plymouth.	1·15 P*	N.E. to S.W.	....	Sharp	III.
" 25	Opunake	1·15 P*	E. to W.	4 secs.	Sharp; building creaked; slight previous tremor and rumbling.	III.+
Nov. 9	Wanganui	3·8 A	S.W. to N.E.	2 min.	Begun and ended gradually; doors, windows, and sash-weights rattled; no rumble.	IV.
" 9	Bulls	3·9 A*	N.E. to S.W.	30 secs.	Smart	III.+
Dec. 8	Wanganui	5·36 P	S.W. to N.E.	Nearly a min.	As on 9th November	IV.
" 10	Opunake	9·39 P*	E.S.E. to W.N.W.	3 secs.	Windows and crockery rattled; long continued rumbling and tremor (before and after).	IV.
1896.						
Jan. 16	Blenheim	9·0¼ P*	N. to S.	2 secs.	Slight	III.
" 16	Opunake	8·59 P*	S.E. to N.W.	3 secs.	Sharp; disturbance of movable objects; considerable and prolonged rumbling and tremor before and after shock; two or three tremors 15 minutes later.	IV.
" 20	Wanganui	After 7 P	S.W. to N.E.	30 secs.	Doors, &c., rattled; no rumble	IV.
" 20	Opunake	About 7·48 P	S.E. to N.W.	30 secs.	Crockery, &c., much shaken; prolonged rumbling and tremor before (and after?).	IV.+
Feb. 19	Wanganui	2 A	S.W. to N.E.	....	Loud explosion and few vibrations	III.−
" 24	"	9·47 P	S.W. to N.E.	20 secs.	Loud rumble; sharp vibrations	III.+
Mar. 24	Opunake	9·44 A*	E. to W.	2 secs.	Slight creaking of building	III.+
Aug. 29	Wanganui	5·36 A	S.W. to N.E.	15 secs.	Sharp vibrations; no noise	III.+
" 31	"	6·21 P	S.W. to N.E.	....	Loud explosion, and few sharp vibrations	III.
Sept. 1	"	10·21 P	S.W. to N.E.	15 secs.	Loud rumble; then moderate vibrations	III.
" 13	"	4·25 A	S.W. to N.E.	About 30 secs.	Five loud explosions (like blows underground), at intervals of less than 1 sec. Moderate vibrations.	III.+

Earthquake Shocks in New Zealand—*continued.*

Date.	Place.	Time of Beginning of Shock—(N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1896.						
Sept. 25	Wanganui	9·25 P	S.W. to N.E.	10 secs.	Loud explosion; then light vibrations	III.
,, 29	,,	8·56 P	S.W. to N.E.	10 secs.	Low rumble; then light vibrations	III.
Oct. 4	Nelson	1·5 P	E. to W.	....	Slight and short	III.—
,, 12	Wanganui	5·25 A	S.W. to N.E.	10 secs.	Low rumble; then doors, &c., rattled	IV.
,, 26	Opunake	4·29 A*	E. to W.	2 secs.	Building creaked; slight previous tremor and rumbling	III.+
Nov. 19	Nelson	1·15 A*	N.E. to S.W.	12 secs.	Sharp; loud rumbling (before)	III.+
Dec. 2	Wanganui	5·48 P	S.W. to N.E.	20 secs.	Jolt and few vibrations, then another jolt; no rumble	III.+
,, 7	Opunake	8·10 P*	E. to W.	2 secs.	Followed by slight rumbling	III.
1897.						
Jan. 24	Wanganui	9 to 9·30 P	S.W. to N.E.	A few secs. each	"Fully twenty rather loud rumbles and slight tremors, at intervals of 2 or 3 minutes" (*sic*).	III.—
Feb. 6	Takaka	1·32 P	N.E. to S.W.	15 secs.	Evidence of direction clear; building rocked violently	IV.
,, 6	,,	2·23 P	N.E. to S.W.	....	Less severe	III.
,, 11	Wanganui	9·3 P	S.W. to N.E.	30 secs. (about)	Loud rumble and sharpish vibrations	III.+
,, 27	Kaikoura	9·4 P*	W. to E.	4 secs.	Very sharp; rumbling 1 or 2 secs. before shock	IV.+
,, 27	Hokitika	9·5 P	N. to S.	50 secs.	Sharp; crockery shaken	IV.
,, 27	Nelson	9·6 P	S. to N.	2 secs.	Sharp	III.+
,, 27	Greymouth	9·7 P*	S.E. to N.W.	30 secs.	Long, steady, undulating movement; rattling of crockery; vibration of chandeliers; no noise.	V.
Mar. 21	Wanganui	2·31 A	S.W. to N.E.	15 secs.	Sharp; no rumble	III.+
April 3	Waotu	8·2 P*	N.E. to S.W.	5 to 7 secs.	Slight; a loud rumble accompanying	III.
May 20	New Plymouth	6·30 P*	S. to N.	10 secs.	Heavy rumbling; then sharp shock	III. to IV.
June 9	Wanganui	0·18 A	S.W. to N.E.	10 secs.	Sharp vibrations	
July 4	Opunake	12·31 P	E. to W.	2 to 3 secs.	Moderate; swinging and rattling of movable objects; considerable previous rumbling and tremor.	IV.
,, 8	Nelson	3 A	E. to W.	2 secs.	Very slight; no noise	III.—
,, 28	Opunake	12·48 A	E. to W.	3 secs.	Sharp; building creaked; loud rumbling	III. to IV.
Aug. 11	Gisborne	8·30½ P*	N.E. to S.W.	30 secs.	Sharp and steady, gradually dying away; distinct rumble heard, then building creaked, &c.; felt by persons in motion.	IV.
,, 30	Nelson	9·30 P	N. to S.	2 secs.	Slight; no noise	III.
,, 30	Opunake	9·32 P*	E. to W.	1 sec.	Sharp and sudden; building creaked as though struck by heavy object; slight previous rumble.	IV.

Earthquakes in South Australia, 1894.

Date.	Place.	Time, Adelaide Mean Time (*verified).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1894.						
Feb. 14	Daly Waters (North Terr.)	4·35 A*	S.W. to N.E.	10 secs.	Wires shaken violently; tables shaken	V.
Mar. 17	Cape Borda (L. House).	1·15 (local)	S.W. to N.E.	19 secs.	Double shock, sharp; doors, etc., rattled; loud report, then rumbling.	III. to IV.
,, 21	Port Augusta	10·43 A*	N.E. to S.W.	10 secs.	Doors, etc., rattled; plaster fell in one house; rumble accompanied.	IV.+
Aug. 7	Kapunda	10·28 P*	N.W. to S.E.	10 to 15 secs.	Furniture shaken, accompanied by rumble	IV. to V.
,, 7	Eudunda	10·30 P	N. to S. ?	sec.	Slight; low rumbling like a cart; windows and crockery rattled.	IV.
Oct. 11	Tanunda	8 P*	N.N.E. to S.S.W.	1½ sec.	Slight, accompanied by low rumbling	III.
Dec. 9	Blinman	1·6 P*	....	....	Crockery rattled, etc.; low rumbling like distant thunder.	IV.
,, 9	Beltana	1·5 P*	N.W. to S.E.	20 secs.	First, a sound as of distant thunder, then louder rumble as of vehicle passing, then sharp shock; iron on roof rattled.	IV to V.

Earthquakes in South Australia in 1897.*

Time = Standard Time ; A. = A.M.; P. = P.M.

Date.	Place.	Time.	Apparent Direction.	Apparent Duration.	Effect—Remarks.	Intensity (Rossi-Forel Scale).
Jan. 28	Blinman	10·30 P.	Not apparent	2 to 3 secs.	Slight tremor	I.
,, 29	,,	9·15 A.	N.W. to S.E.	7 secs.	Rumbling noise; building shook	III.
,, 29	Beltana	9·14 A	Not observable	About 5 secs.	Tremor felt; low rumbling	III.
Feb 9	Blinman	11·40 P	Could not detect	About 5 secs.	Loud rumbling; slightly shook buildings	III.
April 10	Cape Northumberland Lighthouse.	0·30 A	S.W. to N.E.	Half a minute	Sharp shock; tower lamp cylinder rattled very heavy.	III. to IV.
,, 24	Eurelia	6·20 A	N.W. to S.E.	30 secs.	Buildings shook	III.
,, 27	Winabara	8·3 P	N.W. to S.E.	5 secs.	Crockery, windows rattled; rocking felt	III. to IV.
,, 27	Georgetown	8·1 P	S. to N.	30 secs.	Houses shook; much rattling of windows	IV.
,, 27	Gladstone	8·1 P	S. by W. to N. by E.	6 secs.	Crockery shaken; windows rattled and canaries frightened out of their nests.	IV.
May 10	All over colony, and subsequently in S. E.	....	Particulars given elsewhere.			
June 30	Penola	About 4 A	Not given	....	Shook buildings and sheds	
Sept. 5	Port Darwin	3·35 A	W. to E.	5 secs.	Loud rumbling	III.
,, 11	Blinman	4·11 A	N.W. to S.E.	15 secs.	Shook building; loud noise like thunder	III.
,, 11	Beltana	4·12 A	N. to S.	15 secs.	Tremor, with rumbling for several seconds after	III.
,, 11	Hawker	4·15 A	S.W. to N.E.	3 secs.	Sharp shock	III.
,, 19	Winabara	7·53 A	W. to E.	10 to 15 secs.	Tremor felt; loud noise; windows rattled	III.
Nov. 8	Eudunda	0·44½ P	Not apparent	....	Short tremor; loud noise as though below office; sickening sensation.	II. to III.
,, 8	Kapunda	0·44½ P	....	....	Slight	II.
,, 2	Nairne	8·5 P	S.W. to N.E.	....	Tremor; rumbling noise; roof iron rattled	III.
,, 2	Woodside	About 8·5 P.	N.W. to S.E.	....	Short tremor, with rumbling noise	III.
,, 29	Murray Bridge.	About 6 A	....	....	Slight; shook windows	II.

* Excluding the great disturbance on 10th May, which is the subject of a special investigation. *See* Seism. Comm.

VICTORIA AND TASMANIA.

The great South Australian earthquake, of May 10th, 1897, was felt at several places in Victoria and Tasmania. The only other shocks for the period recorded since the last report are slight shocks at Harrow (4th June, 1897,) and at Omeo (5 a.m., 27th September, 1897).

NEW SOUTH WALES.

No returns.

Earthquakes at Weasisi, Tanna, New Hebrides, during 1893—*continued from page 314, Vol. VI.*

(Reported by Rev. W. Gray.)

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1893. Aug. 6	Weasisi	0·45 A	S.S.E. ? to N.N.W. ?	....	Sharp; woke sleepers; shook water tanks	V to VI.
„ 8	„	6·13 P	From S.E. to N.W.	45 secs.	Severe; moved dishes on table	VI.
Oct. 2	„	5·5 P	S. to N.	1 min. to 1½ min.	Very severe; threw clocks off shelves; spilt tea out of cups; upset bottles, tins, &c. Such shocks are felt throughout the group.	VII.
„ 2	„	7·24 P	S. to N.	15 secs.	Sharp; shook house, &c.	IV.
„ 4, 6, 7, 11, 13	„	....	....	....	Slight shocks	II to III.

Volcano began to be active about 15th inst. From 18th to 26th the eruptions were loud and continuous, and fall of dust heaviest for two years. Eruption ceased 26th.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
Oct. 25	Weasisi	10·30 P	?	30 secs.	Severe; double shock	V ?.
Nov. 5	„	7·5 P	S.E. to N.W.	3 secs.	Moderately severe; shook seats	IV.
„ 6, 8, 8, 14, 16	„	....	....	....	Five sharp shocks	IV.
„ 11, 15	„	....	....	....	Two slight shocks	III.
„ 28	„	....	....	....	Two severe shocks; woke sleepers, &c. One slight shock	V to VI. III.
„ 30, Dec. 1, „ 5	„	....	....	....	Three sharp shocks	IV.
„ 12	„	....	....	....	Woke sleepers; severe	V to VI.

N.B.—Other details supplied by Mr. Gray will be placed at the disposal of anyone working at the subject, on application to the Secretary, Seismol. Comm.

No. 2.—"ON OUR KNOWLEDGE OF THE THERMO-DYNAMICS OF THE VOLTAIC CELL."

Report of the Committee, consisting of Professor Lyle, M.A., Mr. W. H. Steele, M.A., and Mr. E. F. J. Love, M.A., F.R.A.S. (Secretary).

INTRODUCTORY NOTE.

YOUR secretary desires to report that, owing to the removal of Mr. W. H. Steele from Melbourne, the active work of the Committee devolved on himself and Professor Lyle. The report which follows was therefore drawn up by your secretary; it was afterwards discussed critically by Professor Lyle, for whose valuable criticism your secretary desires to record his sincere thanks.

REPORT.

1. *Preliminary.*

The application of the laws of thermodynamics to the voltaic cell was first made, in an incomplete manner, by Lord Kelvin,* who showed that the e. m. f. of a Daniell's cell could be deduced with fair accuracy from the results of thermochemical experiments and Faraday's Laws of Electrolysis, by an application of the first law of thermodynamics alone. In the second of the memoirs referred to he shows, however, that this conclusion cannot be regarded as general, pointing out that the "whole chemical action" is not in general—and may possibly not be in any case—electrically efficient, owing to generation of heat within the cell.

The equation given by Lord Kelvin for the Daniell cell may be written—

$$E = \Sigma\,(J\theta\epsilon) \quad \ldots \quad \ldots \quad \ldots \quad (A.)$$

the notation of which is too well known to require explanation. In this form it was made the subject of investigation by many observers, notably Favre, Raoult, and Braun; they soon found that it was far from general, and to Braun† belongs the credit of being the first to suggest the application of the second law of thermodynamics to explain the discrepancies. Almost immediately afterwards Willard Gibbs published his two epoch-making memoirs‡ on "The Equilibrium of Heterogeneous Substances," in

* On the Mechanical Theory of Electrolysis." Phil. Mag. Dec., 1851. "Applications of the Principle of Mechanical Effect to the Measurement of Electromotive Forces," &c. Phil. Mag. Dec., 1851.

† Wied. Ann. V., p. 182, 1878.

‡ Both are contained in Trans. Conn. Acad., iii, 1878.

which a sound thermodynamical theory of the cell was first propounded. Four years later, Helmholtz published the first of a series of memoirs covering between them nearly the whole of the subject. A report "On the present state of our knowledge of the thermodynamics of the voltaic cell" is practically a summary of the work of Helmholtz and his successors.

A word should be said as to the form this report has taken. It practically amounts to a sketch of the theory of the subject, pointing out in regard to each of its divisions the shares contributed to it by the different investigators quoted. In this way the advantage is gained of a uniform notation in the development of the theory; it is hoped that this will render the work more valuable than a string of abstracts of papers arranged in order of time would be.

2. *The Potential Energy of a Reversible System.*

Let the intrinsic energy of any reversible system of bodies be denoted by U, heat supplied to the system by Q, temperature by T, entropy by ϕ, and the n* parameters—independent of each other and of the temperature—which define the state of the system by p_1, p_2, &c.; let the external work done in the variation dp_s of any parameter p_s be denoted by $P_s . dp_s$;

then the first law of thermodynamics may be written—

$$d\,Q = \frac{\delta\,U}{\delta\,T} . d\,T + \Sigma_{s=1}^{s=n} \left\{ \frac{\delta\,U}{\delta\,p_s} + P_s \right\} dp_s \quad \ldots \quad (1)$$

and the second law is expressed by—

$$d\,\phi = \frac{1}{T}\frac{\delta\,U}{\delta\,T} . d\,T + \frac{1}{T} . \Sigma_{s=1}^{s=n} \left\{ \frac{\delta\,U}{\delta\,p_s} + P_s \right\} dp_s \quad \ldots \quad (2)$$

From (2) we obtain at once

$$\left.\begin{aligned} \frac{\delta\phi}{\delta p_s} &= \frac{1}{T}\left\{\frac{\delta U}{\delta p_s} + P_s\right\}, \\ \text{and } \frac{\delta\phi}{\delta T} &= \frac{1}{T} . \frac{\delta U}{\delta T}; \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

whence

$$T\frac{\delta\phi}{\delta p_s} - \frac{\delta U}{\delta p_s} = P_s \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Now suppose that the transformations considered all take place isothermally: then (4) may be written

$$\frac{\delta}{\delta p_s}(T\phi - U) = P_s \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4 \text{ bis})$$

---

* n *must* be finite and integral, but may be as large or small as we please. In ordinary thermodynamics $n=1$, and p_1 = volume of unit mass.

To explain this relation; let us suppose, for example, that p_s denotes a position co-ordinate; then dp_s is a displacement, and P_s the corresponding force. We see at once that $T\phi - U$ is numerically equal, but of opposite sign, to the potential energy of the system. Since this always holds good so long as the parameters are really independent—whatever their number or nature may be—we thus arrive at the following general law :—

In any system of bodies the potential energy of isothermal transformation is given by $U - T\phi$.

If therefore we wish to investigate the direction in which, or the extent to which, any particular isothermal change will take place, it is with this function $U - T\phi$ that we have to deal, and not—or at least, not directly—with the intrinsic energy or entropy of the system.

3. *The Application of the General Law to the determination of Electromotive Force.*

Joule's law tells us that if a quantity dq of positive electrification traverse a circuit in which the e. m. f. is E, the energy liberated isothermally in the circuit is $E\,d\,q$. By suitably arranging the circuit, it is quite imaginably possible—and very nearly so in practice—to obtain all this energy in the form of mechanical work. Let us suppose the necessary arrangements for this effected; and let us further assume that *no external work is done except by the e. m. f.* If then the source of e. m. f. be a reversible cell—*i.e.*, if the transfer through it of a positive quantity $d\,q$ in the reverse direction undoes all the chemical and physical reactions produced by the original transfer—we have at once :—

$$E = -\frac{\delta}{\delta q}(U - T\phi) \quad \ldots \quad \ldots \quad (B)$$

as the thermodynamic equation of e. m. f.

This fundamental relation was first obtained by Willard Gibbs* ; the more general relation (4 bis) was subsequently—but independently—obtained by Helmholtz, † who developed its consequences in a series of memoirs.‡

The quantity $U - T\phi$ has received different names from different investigators. Gibbs calls it the "force-function for constant temperature"; Helmholtz, the "free energy"; Duhem, the "thermodynamic potential at constant volume." "Potential energy of isothermal transformation"§ would probably be the best

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*Trans. Conn. Acad. iii., p. 509, 1878.

† See first of the memoirs cited in the ensuing note.

‡ Sitzungsb. d. Akad. Wiss., Berlin, 1882; Monatsb. d. Akad. Wiss., Berlin, 1883; Sitzungsb. d. Akad. Wiss., Berlin, 1887; Wissenschaftliche Abhandlungen von H. Helmholtz, Vols. ii and iii; translated in "Physical Memoirs" of the Physical Society of London, vol. i.

§ This is really equivalent to Gibbs's name; but physicists are more likely to talk about "potential energies" than about "force functions."

name for it, were the phrase less cumbrous. The term "free energy" has, however, become well established, and will therefore be used in the rest of this report.

We will represent the free energy by F, so that

$$F = U - T\phi;$$

we see at once that F depends only on the actual state of the system, since U and ϕ do so depend.

4. *Consequences of Equation (B). Electromotive Force and Thermal Chemistry.*

The first point to be noted here is that we have no direct relation between E on the one hand and the differential coefficients of U on the other—*i.e.*, we cannot deduce E from thermochemical data alone.* We require, in addition, to know the temperature of the cell and the entropy changes brought about in it by the passage of the current; in fact, we can only calculate the e. m. f. of arrangements for which we can determine beforehand the rate of variation of F.

On the other hand, the converse problem—viz., the deduction, from the electrical behaviour of the cell, of the rate of loss of intrinsic energy during the passage of a current—is often important, and can always be solved, since, as we proceed to show, this rate of loss may be deduced from a knowledge of the e. m. f. and its temperature variation.

$$\text{Since } F = U - T\phi,$$

$$\therefore \frac{\delta F}{\delta T} = \frac{\delta U}{\delta T} - \phi - T\frac{\delta \phi}{\delta T};$$

but, by equations (3),

$$\frac{\delta U}{\delta T} = T\frac{\delta \phi}{\delta T},$$

$$\therefore \frac{\delta F}{\delta T} = -\phi$$

$$\therefore U = F - T\frac{\delta F}{\delta T}$$

$$\text{or } T\frac{\delta F}{\delta T} = F - U.$$

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* In other words, Lord Kelvin's equation (A) is only true provided

$$\frac{\delta \phi}{\delta q} = 0;$$

a fact which at once explains and disposes of the long-standing difficulty as to the difference between the so-called "chemical" and "voltaic" heats.

Differentiating with respect to q we obtain

$$\frac{\delta F}{\delta q} - \frac{\delta U}{\delta q} = T \frac{\delta}{\delta q}\left(\frac{\delta F}{\delta T}\right);$$

$$= T \frac{\delta}{\delta T}\left(\frac{\delta F}{\delta q}\right),$$ since F depends only

on the state of the system ;

$$\text{but } \frac{\delta F}{\delta q} = -E$$

$$\therefore E - T\frac{\delta E}{\delta T} = -\frac{\delta U}{\delta q} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

In accordance with Faraday's law $-\frac{\delta U}{\delta q}$ is simply the algebraic sum of the heats of formation of one electrochemical equivalent of each of the active substances produced in the cell. Since the heat evolved in any chemical reaction is, for a given temperature, simply proportional to the amount of new substance produced, we may write (5) thus

$$H = E - T\frac{\delta E}{\delta T} \quad \ldots \quad \ldots \quad \ldots \quad (C)$$

where H denotes the net heat *evolved* by the formation of one electrochemical equivalent of each of the active substances. H is of course reckoned here in ergs. If now we denote by σ the electrochemical equivalent of hydrogen, and by J the mechanical equivalent of heat, (C) becomes

$$H^1 = \frac{1}{J\sigma}\left(E - T\frac{\delta E}{\delta T}\right)$$

where H^1 denotes the algebraic sum of the "heats of formation"—as ordinarily tabulated—of the solutions in the cell. This calculation enables us to deduce thermochemical constants from electrical data.

The equation (C) was established by Helmholtz* in the first of the memoirs cited above, and is now well known as "Helmholtz's Law." It has been verified in a large number of cases, and now takes rank as a well-attested physical law. The first experiments on the subject are those of Czapski†; these, however, did little more than indicate the superiority of Helmholtz's law over the relation advanced by Lord Kelvin ; they cannot be looked on as affording a rigorous verification. This has since been supplied by Gockel‡ and Jahn§ ; the lastnamed observer determined by means

* Helmholtz's method of investigation differs from that given here ; but it seemed advisable to show that the law is directly deducible from the properties of the function F.

† Wied. Ann. xxi, p. 209.

‡ Wied. Ann. xxiv, p. 618.

§ Wied. Ann. xxviii, p. 21.

of an ice calorimeter the heat evolved by the chemical actions taking place in a large number of cells, whose e. m. f.'s he also determined; the temperature coefficients were then deduced for the different cells, and found to be in good agreement with the values determined directly, in some cases by Gockel, in others by Jahn himself.

5. *Electromotive Force and Peltier Effect.*

It is now necessary to account for the energy dissipated in the cell, other than that dissipated in accordance with Joule's Law. This dissipation of energy, denoted by $-\mathrm{T}\frac{\delta \mathrm{E}}{\delta \mathrm{T}}$, is obviously due to a *reversible* generation of heat; this being so, we see that if the current through the cell be reversed—say by a dynamo—the energy which the reversing dynamo needs to expend will be less or greater than the mechanical equivalent of the heat absorbed in the reversed chemical actions, according as the cell absorbs or evolves heat reversibly in its direct action.

Now we know one such class of reversible heat actions in the circuit, viz.:—thermoelectric actions at the various junctions of dissimilar substances; and we note at once that the mathematical form taken by a thermoelectric e. m. f. is identical with that of the term $\mathrm{T}\frac{\delta \mathrm{E}}{\delta \mathrm{T}}$. For if κ denote the thermoelectric e. m.f. in a circuit consisting of two substances whose junctions are maintained at different temperatures, we know that Π, the coefficient of the Peltier effect at either junction, is given by $\mathrm{T}\frac{\delta \kappa}{\delta \mathrm{T}}$, where T denotes the temperature of the junction considered.

Now there are several such junctions in any voltaic circuit; if then we denote by $\Sigma\,(\Pi)$ the sum of their Peltier effects we know *a priori* that

$$-\mathrm{T}\frac{\delta \mathrm{E}}{\delta \mathrm{T}} \lesseqgtr \Sigma\,(\Pi)$$

To assume off hand that $-\mathrm{T}\frac{\delta \mathrm{E}}{\delta \mathrm{T}}$ is equal to $\Sigma\,(\Pi)$ amounts to asserting the absence of any source of reversible generation of heat other than the Peltier effects; an assumption we have no right to make—though it often was made—without experimental evidence. This has been supplied by Jahn* and Gill,† who independently measured the Peltier effects at the bounding surfaces

* Wied. Ann. xxxiv, p. 755; l, p. 189. The second paper corrects some errors in the first.
† Wied. Ann. xl, p. 115.

in different cells; they find that for all the cases which they have examined the equation

$$- T \frac{\delta E}{\delta T} = \Sigma (\Pi)$$

holds good within the limits of experimental error.

Hence we obtain

$$E + \Sigma (\Pi) = - \frac{\delta U}{\delta q} = H \quad \ldots \qquad \ldots \quad (D.)$$

an equation which Jahn* has applied to the determination of heats of combustion. These investigations of Jahn and Gill cover between them such a wide range of chemical actions as to warrant us in regarding equation (D)—provisionally at least—as generally applicable.†

6. *Electromotive Force and Dissociation.*

In a communication addressed to the Electrolysis Committee of the British Association,‡ Willard Gibbs expresses the relation between e. m. f. and heat of formation in a different form. Denoting by T_0 the "temperature of transformation"—*i.e.*, the temperature at which the chemical action which gives rise to the current would go on indiscriminately in either direction§—Gibbs goes on to assume that the cell may be treated as a case of Carnot's cycle,‖ and from this assumption he easily deduces—

$$E = H \, . \, \frac{T_0 - T}{T_0}, \quad \ldots \qquad \ldots \quad (E)$$

where H has the same signification as in (C) and (D).

This equation is of great practical importance, inasmuch as if any two of the quantities E, H, and T_0 be known the third can be determined by applying it. Cohen¶ has verified it throughout in several cases, and has made it the basis of an electrical method of determining transformation temperatures, which gives results in very close agreement with those obtained by other methods, where such are applicable. Van't Hoff, Cohen, and Bredig** in a joint memoir combine the equation of Gibbs with that of Helmholtz and compare the results with experiment, thus verifying both at once.

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* Wied. Ann. xxxvii, p. 408.

† This equation was indeed assumed by Lodge even before Jahn's work had rendered the assumption justifiable. See B. A. Report, 1887, p. 340.

‡ B. A. Rep. 1886, p. 388. See also a criticism by Prof. Lodge, B. A. Rep. 1887, p. 340; and Prof. Gibbs's reply, B. A. Rep. 1888, p. 343.

§ The lowest temperature of complete dissociation of a chemical compound is a special case of a transformation temperature.

‖ Whether or no this assumption is in general justifiable seems to be a little doubtful; and, so far, Gibbs' proof may be regarded as open to question. His result however appears, as far as experiments have conducted us up to the present, to be quite correct.

¶ Zeitsch. für Phys. Chem. xiv, pps. 53, 535; Cohen attributes the relation to Van't Hoff, but Gibbs' investigation preceded Van 't Hoff's.

** Zeitsch. für phys. Chem. xvi, p. 453.

7. *Summary of Expressions for Electromotive Force.*

We have now the following expressions for the relation between the e. m. f. of a cell and various thermodynamic quantities :—

$$E = -\frac{\delta}{\delta q}(U - T\phi) = -\frac{\delta F}{\delta q} \quad \dots \quad \dots \quad (B)$$

$$E - T\frac{\delta E}{\delta T} = -\frac{\delta U}{\delta q} = H \quad \dots \quad \dots \quad \dots \quad (C)$$

$$E + \Sigma(\Pi) = -\frac{\delta U}{\delta q} = H \quad \dots \quad \dots \quad \dots \quad (D)$$

$$E = \Pi \cdot \frac{T_0 - T}{T_0} \cdot \quad \dots \quad \dots \quad \dots \quad \dots \quad (E)$$

The practical utility of the expressions (C), (D), and (E) has been already indicated; that of (B) is due to the fact that $\frac{\delta F}{\delta q}$ is sometimes calculable when nothing can be directly determined with regard to ϕ and its differential coefficients.

8. *Electromotive Force and Free Energy.*

Helmholtz has calculated the variation of free energy due to the passage of the current in two important cases, and compared the results with experiment.

(*a*) Liquid cells.

At the surface of contact of two solutions, of the same electrolyte but of unequal strengths, an e. m. f. is set up; if the circuit be closed by means of nonpolarisable electrodes a current will flow, and will go on flowing with gradually diminishing intensity until the concentrations become equalised; in this way work may be obtained from the arrangement. The liquid cell thus constituted is reversible; for the passage of a current through it in the opposite direction will set up a difference of concentration. In this particular case, however, the results are complicated by the Peltier effects; Helmholtz eliminated these by employing two calomel cells,* similar in all respects save that the solutions of zinc chloride contained in them were of different strengths; coupling these so as to oppose each other, the resulting e. m. f. is the same as that of a liquid cell without Peltier effects—since every kind of junction is traversed in both directions†—a "simple liquid cell" as it may be termed; the only sources or sinks of energy being (*a*) the solution of zinc chloride in the weaker cell, (*b*) its passage out of solution in the stronger.

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* The calomel cell is arranged thus—

$$Zn \mid Zn\,Cl_2 \mid Hg_2\,Cl_2 \mid Hg$$

† The inequality in the concentration of the zinc chloride solutions does not give rise to any difficulty, as experimenters agree in affirming that the Peltier effects at the boundary of electrolytic solutions are (*a*) small, (*b*) independent of the concentration. The insoluble character of the calomel also helps in the same direction.

Now suppose a quantity dq of electricity pass through the cells, during which process an amount ds of the salt is dissolved in the weaker solution, and passes out of solution in the stronger; then if ϵ denote the electrochemical equivalent of the salt—*i.e.*, the amount dissolved per unit current — then $\frac{ds}{\epsilon} = dq$.

Hence in accordance with what has gone before—equation (B)—

$$E = -\frac{\delta F}{\delta q} = -\epsilon \cdot \frac{\delta F}{\delta s}.$$

The quantity $\frac{\delta F}{\delta s}$ cannot be directly calculated, but we may determine it indirectly as follows:—

If a quantity of water dw be evaporated from the weaker solution and condensed into the stronger, the work done is $-\frac{\delta F}{\delta w} d w$. Now $\frac{\delta F}{\delta w}$ can be calculated from a knowledge of the maximum pressures of aqueous vapour above the solutions—this calculation is given later—if then we can determine the relation between $\frac{\delta F}{\delta s}$ and $\frac{\delta F}{\delta w}$ we can deduce the value of the former, and consequently the e. m. f. of the liquid cell.

The required relation is obtained as follows:—

Let us divide F into two parts, F_1 and F_2, belonging respectively to the weaker and stronger solutions.

$$\text{Then } -\frac{\delta F}{\delta w} = -\frac{\delta F_1}{\delta w} + \frac{\delta F_2}{\delta w}.$$

Let w and s denote the masses of water and salt in the weaker solution.

Put $\frac{w}{s} = h$; and let f_h denote the work done in separating unit mass of the solution into water and salt

$$\therefore F_1 = (w + s) f_h = s\,(1 + h) f_h$$

If we vary w by evaporation or condensation, keeping s constant, we have

$$\frac{\delta F_1}{\delta w} = s \cdot \frac{\delta}{\delta h}\Big[(1 + h) f_h\Big] \cdot \frac{\delta h}{\delta w},$$

$$= \frac{\delta}{\delta h}\Big[(1 + h) f_h\Big]$$

If on the other hand we vary s by abstraction or addition of salt, keeping w constant, we obtain

$$\frac{\delta F_1}{\delta s} = (1+h) f_h + s . \frac{\delta}{\delta s} \Big[(1+h) f_h \Big],$$

$$= (1+h) f_h - h \frac{\delta}{\delta h} \Big[(1+h) f_h \Big].$$

$$\therefore \frac{\delta^2 F_1}{\delta s . \delta h} = - h . \frac{\delta^2}{\delta h^2} \Big[(1+h) f_h \Big] = - h . \frac{\delta^2 F_1}{\delta w . \delta h} \quad \ldots \quad (6)$$

We must now determine $\frac{\delta F_1}{\delta w}$ as a function of h. In the first place we observe that

$$\frac{\delta F_1}{\delta w} = - \int_{h=\infty}^{h=h} p . dv ,$$

where p denotes the vapour pressure and v the corresponding specific volume. Then, as Helmholtz has shown in the second of the memoirs above referred to, we may evaluate this integral as follows :—

First, let the amount dw evaporate from pure water under saturation pressure P and specific volume V ; this does an amount of work $= \mathrm{P.V.}\ dw$.

The vapour is then expanded—out of contact with water—till it attains the specific volume v_h and saturation pressure p_h of the vapour overlying the solution ; this does a further amount of

$$\text{work} = dw \int_V^{v_h} p . dv.$$

Finally the vapour is compressed in contact with the solution under constant pressure p_h until it condenses. This absorbs work $= p_h . v_h . dw$.

$$\therefore \frac{\delta F_1}{\delta w} = - \mathrm{P\,V} - \int_V^{v_h} p . dv + p_h v_h$$

or, by partial integration

$$\frac{\delta F_1}{\delta w} = \int_P^{p_h} v . dp. \quad \ldots \quad \ldots \quad (7)$$

We can now determine an expression for the e. m. f. in terms of calculable quantities.

Since $\frac{\delta F_1}{\delta w}$, v, and p are all functions of h, we may differentiate equation (7) with respect to h, and we get

$$\frac{\delta^2 F_1}{\delta w . \delta h} = v . \frac{\delta p}{\delta h}$$

$\therefore$ by (6)

$$\frac{\delta^2 F_1}{\delta s . \delta h} = - h . v . \frac{\delta p}{\delta h}$$

$$\therefore - \frac{\delta F_1}{\delta s} = \int_{h=\infty}^{h=h} h . v . \frac{\delta p}{\delta h} . dh .$$

Similarly, if we denote the ratio of water to salt in the second solution by k, we may show that—

$$- \frac{\delta F_2}{\delta s} = \int_{h=\infty}^{h=k} h . v . \frac{\delta p}{\delta h} . dh.$$

$$\therefore E = - \epsilon \frac{\delta F}{\delta s} = - \epsilon \left(\frac{\delta F_1}{\delta s} - \frac{\delta F_2}{\delta s} \right) = \epsilon \int_k^h h . v . \frac{\delta p}{\delta h} . dh \ldots \text{(F)}$$ *

We now have to evaluate the integral in equation (F). For moderate temperatures the expression may be simplified, since the density of saturated vapours is small at such temperatures, even for pure water; we may therefore assume that the aqueous vapour obeys the laws of a perfect gas—an assumption which Regnault has shown to hold good so long as the saturation density is small. We have, therefore,

$$\frac{P V_0}{T_0} = \frac{P V}{T} = \frac{p v}{t}$$

where the capital letters refer to saturated vapour overlying pure water, the small ones to that above a solution.

Hence equation (F) transforms into

$$E = \epsilon . \frac{t . P_0 . V_0}{T_0} \int_k^h h . \frac{\delta \log p}{\delta h} . dh .$$

Helmholtz determined an empirical formula expressing the relation between p and h for zinc chloride solutions, evaluated the integral by its means, and deduced the values of E at 0° C. for pairs of solutions of various strengths; the calculated values agreed very closely with those subsequently obtained by experiment.

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* The analysis as given here is considerably altered from that in Helmholtz's memoir, to which Baynes has justly taken exception. (See "Physical Memoirs" of the Physical Society, Vol. I, list of errata.) The final result is, however, the same in both cases.

In an earlier memoir Helmholtz* had discussed the e. m. f. of liquid cells from a different point of view. Taking such a cell as

$$\text{Cu} \mid \text{Cu SO}_4 \text{ dil} \mid \text{Cu SO}_4 \text{ strong} \mid \text{Cu}$$

he showed that the e. m. f. could be deduced thermodynamically from the vapour pressures, the electrochemical equivalent of the salt, and Hittorf's migration constant. If we suppose 1 equivalent of the salt to be dissolved in a quantity w_a of water in one solution, and in w_k in the other, and if μ denote the migration constant, Helmholtz finds

$$E = \int_{p_k}^{p_a} w \, . \, (1 - \mu) \, . \, v \, . \, dp\dagger \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

For a moderate range of concentrations the following relation holds good—

$$P - p = \frac{b}{w}$$

where b is constant. In such cases (8) reduces to

$$E = b \, . \, V \, . \, (1 - \mu) \, . \, \log \frac{w_a}{w_k} \, .$$

The accuracy of the calculation of e. m. f.'s by this formula was confirmed experimentally by J. Moser‡; but, as Helmholtz himself pointed out, the introduction into the theory of migration constants—which are not known with any great accuracy§—is a source of weakness in the method as far as the verification of the thermodynamic theory is concerned, for which purpose he gives the preference to the experiments with opposed cells.

This mode of investigation has however been applied by Moser‖ to the more accurate determination of migration constants, from measurements of e. m. f., vapour pressure, and concentration; but very little has so far been done in this way, though it would seem to open up a promising line of research.

(*b*) The relation between the e. m. f. required for the decomposition of water and the pressure of the evolved gases.

In his third memoir on the "Thermodynamics of Chemical Processes" Helmholtz treats this case at great length, obtaining expressions for the free energies of water and of detonating gas, and deducing the e. m. f. of a gas-battery. All his results contain, however, an arbitrary constant, so that only differences are of any practical use; the calculations of e. m. f. possessing individually

* Monatsb. d. Akad. der Wiss., Berlin, 1877; Wied. Ann. iii, p. 201; Phil. Mag. [5], V., p. 348.
† The analysis is not reproduced, being quite straightforward; the notation in the results is altered to agree with that employed in the previous discussion.
‡ Wied. Ann. iii, p. 201.
§ We are indeed almost in the dark as to the relation between the migration constant and the concentration.
‖ Sitzungsb. d. k. Akad. der Wiss. Wien, Bd. xcii. Abth. ii, p. 652.

only a theoretical value—if that. The net result of the discussion is a determination of the effect of pressure on the e. m. f. of a Grove's gas-battery; as Helmholtz's analysis is very cumbrous, and as this is merely a special case of the problem discussed in section 10—where the whole question is shown to be susceptible of very simple treatment—only the results are given here.

Let E_1 = e. m. f. under pressure p_1 of the mixed gases.
,, E_2 = e. m. f. ,, p_2 ,, ,,
,, $p_2 = p_h + p_o$; where
p_h = partial pressure due to hydrogen.
p_o = ,, ,, oxygen.
Let a_h, a_o denote the atomic weights of hydrogen and oxygen.
,, v_h, v_o ,, specific volumes ,, ,,
,, ϵ = electrochemical equivalent of water.
,, $R_h = \dfrac{p_h\, v_h}{t_h}$; $R_o = \dfrac{p_o\, v_o}{t_o}$

Then Helmholtz finds

$$E_2 - E_1 = 10^{-7}.\epsilon.T\left\{R_h.\frac{2\,a_h}{2a_h + a_o}.\log_e\frac{p_h}{p_1} + R_o.\frac{a_o}{2a_h + a_o}.\log_e\frac{p_o}{p_1}\right\}\ldots(G)$$

In a fourth memoir* Helmholtz compares this formula with the results of his own experiments. The agreement is, to all appearance, satisfactory; but is in reality illusory, being due to an error in computation. He shows that the formula simplifies into

$$E_2 - E_1 = \frac{1}{6} \times 10 - 7 \times 0{\cdot}00009319 \times T \times R_h \times \log_e\left(\frac{p_2}{p_1}\right)$$

$$= 0{\cdot}018868 \log_e\left(\frac{p_2}{p_1}\right);$$

and gives as the result of the calculation, when $p_1 = 10$ mm. of mercury, $p_2 = 742$ mm.,

$$E_2 - E_1 = 0{\cdot}1305.$$

This agrees fairly well with his experiments; but it is not correctly calculated. If we substitute the values of the logarithms and work out the result we obtain—

$$E_2 - E_1 = 0{\cdot}0813,$$

which is not in agreement with Helmholtz's observations, but agrees well, as we shall find in section 10, with the much more extended researches of Gilbault.

* Sitzungsb. d. Akad. der Wiss., Berlin, 1887, p. 749; "Physical Memoirs" of the Physical Society of London, Vol. i, p. 98.

9. *Free Energy and Polarisation.*

In an interesting memoir, Jahn and Schönrock* have investigated the polarisation set up during the electrolysis of a solution between platinum electrodes, from the point of view of changes of free energy. They write down the terms which include the changes of intrinsic energy and entropy due to every transformation which goes on, both at the anode and at the kathode, and also in the body of the solution—owing to ionisation—and thus obtain, in the simplest and most direct manner possible, an expression for the change of the free energy of the system, in terms of the changes both of its intrinsic energy and of the entropies of its constituents. As the first attempt to apply the laws of thermodynamics to the modern theory of electrolysis the paper has great value; the theoretical conclusions advanced in it are, moreover, confirmed by experiment. The results may be summed up as follows:—

(1.) The maximum polarisation for all salts formed from heavy metals and the radicles of strong oxyacids is the same.

(2.) The polarisation of a cell containing a dilute oxyacid must be increased by increasing the external pressure; moreover it has the same value for all oxyacids, whether strong or weak, at the same pressure.

(3.) The maximum polarisation in an oxyacid cell is independent of the concentration of the acid solution.

(4.) The maximum polarisation in an alkaline solution is identical with that in an oxyacid solution.

(5.) The maximum polarisation in a dilute salt solution will always exceed that in the corresponding acid; the difference between the two being equal to the change of free energy brought about by the dissociation of water into hydrogen and hydroxyl ions.

10. *Relation between Electromotive Force and External Pressure.*

Let the action of a cell result in the performance of external work, not only in the circuit in accordance with Joule's Law, but also in changing its own volume against external pressure during the passage of the current. If no other work is done we may write equation (2)—of section (2)—thus

$$d\,\phi = \frac{1}{\mathrm{T}}\left\{\frac{\delta\,\mathrm{U}}{\delta\,\mathrm{T}}.\,d\,\mathrm{T} + \frac{\delta\,\mathrm{U}}{\delta\,q}.\,dq + \frac{\delta\,\mathrm{U}}{\delta\,v}.\,dv + \mathrm{E}\,.\,dq + p\,.\,dv\right\},$$

where p and v denote the external pressure† and the volume of the cell respectively.

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* Zeitsch. für phys. Chem., xvi, p. 45.

† Whether it be due to electrolytic gas or anything else.

Hence we have

$$T\,.\,d\phi - d\,U = E\,.\,dq + p\,.\,dv.$$

Subtract $d\,(pv)$ from both sides; we obtain

$$T\,.\,d\phi - d\,U - d\,(pv) = E\,.\,dq - v\,.\,dp$$

or, for constant temperature

$$d\,(U - T\,\phi + p\,v)^* = -E\,.\,dq + v\,.\,dp.$$

Since the left-hand member of this equation is a perfect differential, the right-hand member is also a perfect differential; hence we obtain at once

$$-\left(\frac{\delta E}{\delta p}\right)_{q\text{ const.}} = \left(\frac{\delta v}{\delta q}\right)_{p\text{ const.}} \quad \ldots \quad \ldots \quad (9)$$

From this equation we see that

(1.) If the volume of a cell is altered by the passage of a current through it, the e. m. f. is a function of the external pressure.

(2.) The e. m. f. increases with the pressure if the volume of the cell diminishes when it generates a current; and the e. m. f. diminishes as the pressure rises if the volume of the cell increases while the cell generates a current.

These laws were demonstrated—though by somewhat less direct reasoning than that employed here—by Duhem.† They were afterwards made the subject of an extended investigation by Gilbault,‡ whose valuable memoir has hitherto received far less attention than it deserves.

In accordance with Faraday's law equation (9) becomes, for constant pressure,

$$-\frac{\delta v}{\delta q} = \frac{v_0 - v_1}{q} \ldots \quad \ldots \quad \ldots \quad (q.p.)$$

where v_0 = initial volume of cell
v_1 = final ,, ,,
q = quantity of electrification which has traversed it

Hence $q\,\dfrac{\delta E}{\delta p} = v_0 - v_1$.

This equation is easily integrated for solids and liquids, seeing that in them v_0 and v_1 are sensibly independent of the pressure; the integration is equally easy for gas-cells, provided we assume Boyle's law to hold good throughout the range of pressure employed. We may therefore write for solids and liquids,

$$E_1 - E_0 = \frac{v_0 - v_1}{q}\,(p_1 - p_0) \quad \ldots \quad \ldots \quad \ldots \quad (H)$$

* The function $U - T\,\phi + p\,v$ is termed by Duhem the "thermodynamic potential at constant pressure."

† Duhem; "Le Potential Thermodynamique et ses Applications," p. 117.

‡ Ann. de la Fac. des Sci. de Toulouse, Vol. V, p. A 5; C.R., 1891, p. 465.

For gas-batteries, putting V = volume at one atmosphere pressure of one electrochemical equivalent of gas, we obtain

$$E_1 - E_0 = V \log_e\left(\frac{p_1}{p_0}\right) \quad \ldots \quad \ldots \quad (K)$$

Gilbault submitted equations (H) and (K) to the test of experiment for a large number of cells, and over a range of pressure from 1 to 500 atmospheres; and found a very satisfactory agreement between the calculated and observed changes of e. m. f. The change produced in the e. m. f. of a Daniell's cell by applying a pressure of 100 atmospheres is about the hundreth part of that produced in Grove's gas-battery; it is, however, quite measurable, and the results agree with theory equally well in both cases. Small outstanding differences are ascribed by Gilbault, in the case of solids and liquids, to secondary chemical actions, which—though not fully investigated—were definitely shown to occur at high pressures; similar discrepancies in the case of gases are ascribed partly to the cause abovementioned, partly to the failure of Boyle's Law.*

APPENDIX.

It seems only fair to point out that several of the results here exhibited as deductions from the laws of thermodynamics can be obtained by totally different methods, some of which may fairly claim a degree of generality little, if at all, inferior to that possessed by the methods of thermodynamics.

Thus the relation between the e. m. f. of a gas-cell and the external pressure has been deduced by J. J. Thomson† directly from the Lagrangian function without subsidiary assumptions, thus proving it to be amenable to strictly dynamical reasoning. Again, by combining with the principle of least action the assumption—which has much to recommend it—that "the portion of the energy of a system which contains the temperature as a factor is essentially kinetic," Thomson has deduced‡ an expression practically identical with equation (C), *i.e.*, with Helmholtz's law. It must, however, be admitted that, in view of the assumption which it contains, this part of his investigation cannot lay claim to the same strictly dynamical character as the other.

Finally it may be mentioned that Nernst's theory of electromotive force leads directly to Helmholtz's law§; but Nernst's theory lacks the generality possessed by those founded either on dynamical or thermodynamical considerations.

* The e. m. f. of a gas-cell is equal and opposite to the counter-electromotive force of polarisation in a water-voltameter at the same pressure; hence the relation between the e. m. f. needed to decompose water and the pressure is given by equation (K). Substituting the known value of V this becomes

$$E_1 - E_0 = 0{\cdot}01886 \log_e \left(\frac{p_1}{p_0}\right),$$

which is identical with the result obtained by Helmholtz's calculations. Gilbault verified this expression over a tolerably wide range of pressures.

† "Applications of Dynamics to Physics and Chemistry," p. 86.

‡ "Applications of Dynamics to Physics and Chemistry," p. 98.

§ See Ostwald, "Lehrbuch der allgemeinen Chemie," vol. ii, pt. i, p. 859.

No. 3.—ON THE COMPOSITION AND PROPERTIES OF THE MINERAL WATERS OF AUSTRALASIA.

Report of the Committee, consisting of Professor A. Liversidge, F.R.S., Mr. W. Skey, F.C.S., and Mr. G. Gray, F.C.S. (Secretary).

REPORT.

In the following Report, the composition only of the mineral waters of Australasia is dealt with. Analyses have been collected from all available sources, and the results arranged in geographically alphabetical order under the names of the respective colonies. The list is necessarily incomplete, and the information given in some cases is of a fragmentary character. Considerable work yet requires to be done in the classification of the waters, and in gathering information regarding their therapeutic qualities.

The results generally are expressed in grains per gallon, and for the purpose of so doing it has been found necessary to recalculate them in some cases. With regard to the New Zealand waters, the labour of collecting results has been much reduced by a free use of the information given in the official Year Book, 1896, which contains an article by Sir James Hector on the subject.

The thanks of the Committee are due to those gentlemen who assisted by furnishing particulars relating to waters coming under their notice.

NEW ZEALAND.

Abbotsford, Otago.—W. Skey. XVIIth Colonial Museum and Laboratory Report, 1881–2, p. 54.

Acid chalybeate water.—Total solids, 304·01 grs. per gal.; sulphuric acid, 191·87. Contains considerable quantity of ferrous oxide and a little ferric oxide in combination with sulphuric acid, also free sulphuric acid; deposits basic peroxide of iron compound on boiling.

Akitio, Wellington.—W. Skey. Transactions, New Zealand Institute, vol. X, p. 447.

Chalybeate water.—Total solids, 37·65 grs. per gal.; lime, 13·14; soda, with a little potash, 4·68; magnesia, 2·32; iron and alumina, ·93; carbonic acid combined, 9·57; sulphuric acid, 1·02; chlorine, 1·84; silica, 4·15; charged with free carbonic acid. Valuable as a tonic; similar to the waters of Pyrmont (Waldeck), and Recoaro (Venetia).

Amberley, Canterbury.—A. W. Bickerton. New Zealand Official Year Book, 1896, p. 434.

Chalybeate water.—Total solids, 37·6 grs. per gal.; volatile, 8·8; chlorine, 10·5; carbonate of lime, 3·6; carbonate of magnesia, 2·2; iron protoxide, 2·3; soda, &c., 10·2. Contains a high proportion of organic matter.

Auckland.—W. Skey. XVth Colonial Museum and Laboratory Report, 1879–80, p. 43.

Alkaline water.—Total solids, 116·78 grs. per gal.; sodic bi-carbonate, 42·89; calcic bi-carbonate, 14·25; magnesia bi-carbonate, 45·15; sodic chloride, 3·81; aluminia oxide, ·30; sodic sulphate, ·04; silica, 10·31.

Bay of Islands, Auckland.—W. Skey. Transactions, New Zealand Institute, vol. X, 1877, p. 424.

Acid, sulphuretted, and chalybeate, water.—Total solids, 134·6 grs. per gal.; fixed alkalies, 41·66; protoxide of iron, 2·23; lime, 5·97; magnesia, 1·15; silica, 3·10; sulphuric acid, 13·60; hydrochloric acid, 66·91. This water has a slight acid reaction and strong odour of sulphuretted hydrogen; forms a deposit of sulphur and sulphates.

Blind Bay Estate, Lake Grassmere.—W. Skey. XXIXth Colonial Museum and Laboratory Report, p. 20.

Total solids, 5·82 grs. per gal, consisting of sodic chloride, calcic chloride, and sodic sulphate; contains also minute traces of iodine combined with magnesia.

Cannibal Gorge, Reefton.—W. Skey. XXth Colonial Museum and Laboratory Report, p. 52.

Sulphuretted and chalybeate water.—Total solids, 36·66.; sodium chloride, 18·02; calcium sulphate, 5·44; sodium sulphate, 2·20; calcium sulphide, 2·81; magnesia sulphide, 1·26; carbonate of iron, ·91; silica, 6·02; sulphuretted hydrogen is present to the extent of 6·91 grs. per gal.

Dungree.—W. Skey. XVIth Colonial Museum and Laboratory Report, 1880–1, p. 47.

A chlorinated saline water, said to be avoided by cattle and sheep.—Total solids 94·6 grs. per gal., mainly sodium chloride, with chlorides and sulphates of the alkaline earths, a small quantity of earthy carbonates, and a trace of magnesia iodide. Reaction distinctly alkaline.

Gibson Station, Southland.—W. Skey. Transactions, New Zealand Institute, vol. X, 1877, p. 448.

Total solids, 26·0 grs. per gal. Fixed salts, 18·51, consisting of alkaline chlorides and carbonates, with considerable quantity of ferric salts. Volatile matter principally organic matter, 7·5 grs. per gal. This water is said to be a specific for diarrhœa, probably due to some astringent substance present in the organic matter.

Great Barrier Island.—C. P. Winkelmann. Transactions, New Zealand Institute, vol. XIX, p. 388.

(1.) Sulphuretted water, held by the natives to be a specific for rheumatism; acts internally as a mild aperient. Temperature, 186° F.

(2.) Sulphuretted water, considered by natives to be specially useful in skin diseases. Temperature, 142° F.

Hanmer Plains, Nelson.—J. von Haast. Transactions, New Zealand Institute, vol. III, p. 293. Hector, *Ibid*, vol. III, p. 297. Skey, *Ibid*, vol. X, p. 447. Hector, New Zealand Official Year Book, 1896, p. 433.

Sulphuretted and alkaline waters.—Ten springs, four cold and six thermal, with temperatures ranging from 83° to 140° F. The waters from the several springs are similar in composition.

Total solids, 77·38 grs. per gal.; sodium chloride, 62·09; potassium chloride, ·15; sodium sulphate, 7·48; sodium carbonate, 2·66; magnesium carbonate, 1·77; calcium carbonate, ·55; ferrous carbonate, ·05; silica, 2·63, with traces of iodine, lithum, and aluminium phosphate. Reaction strongly alkaline. The waters smell strongly of sulphuretted hydrogen, which is present to the extent of 2·19 grs. per gal. A sediment is formed consisting of silica and free sulphur. Large quantities of free and albuminoid ammonia are present, but the water is not injurious to drink, and, in many cases, has been found beneficial. When used for bathing purposes, the water is said to be useful in cases of rheumatism, sciatica, gout, cutaneous diseases, nervous affections, insomnia, chest complaints, and also for asthma (from Oct. to June only), and psoriaris (from Sept. to April only).

Helensville.—W. Skey. XXIIIrd Colonial Museum and Laboratory Report, p. 68.

Chlorinated water.—Temperature, 140° F.; reaction very alkaline; total solids, 129·37 grs. per gal.; sodium chloride, 109·19; calcium chloride, 5·42; potassium chloride, 1·02; calcium carbonate, 4·67; magnesium carbonate, 1·49; calcium sulphate, 1·03; alumina, ·45; silica, 6·10, with traces of iron. oxides and magnesia iodide.

Hokianga.—J. A. Pond. Transactions, New Zealand Institute, vol. XI, p. 512.

Chlorinated siliceous water.—Total solids, 2937·55 grs. per gal.; sodium chloride, 2797·4; potassium chloride, 1·9; magnesium carbonate, 18·71; soluble silica, 49·56; organic matter, 51·11, with traces of lime, iron, and sulphuric anhydride.

Kopuowhara Mahia.—W. Skey. XVIIth Colonial Museum and Laboratory Report, p. 55; *Ibid.*, XIXth, p. 39.

Chlorinated water.—Total solids, 1241·65 grs. per gal.; sodium chloride, 1027·6; potassium chloride, 2·99; calcium chloride, 177·82; calcium sulphate, 2·61; magnesium carbonate, 1·49; calcium carbonate, 3·71; aluminum chloride, 16·42; aluminum phosphate, ·37; magnesium iodide, 2·98; silica, 5·60; ferric chloride traces; total iodine, 2·02 grs. per gal.

Kummerstein Wharcama.—W. Skey. XXVIth Colonial Museum and Laboratory Report, p. 37.

A chlorinated water of considerable strength, containing iodine in notable quantity.

Maketu.—W. Skey. XXth Colonial Museum and Laboratory Report, p. 52.

Acid water.—Total solids, 130·27 grs. per gal.; sulphuric acid (free), 77·11; sodium sulphate, 8·21; potassium sulphate, traces; calcium sulphate, 5·42; magnesium sulphate, 1·39; alumina and iron oxide, 12·18; silica, 25·96.

Masterton, Upper Tararu Road.—W. Skey. XXVIth Colonial Museum and Laboratory Report, p. 38.

Sulphuretted chlorinated water.—Feeble alkaline reaction; Total solids, 224·3 grs. per gal.; organic matter, 3·2; sulphuretted hydrogen, 1·6.

Motukaramu.—Spring near the River Mokau.—W. Skey. XXIInd Colonial Museum and Laboratory Report, p. 57.

A chlorinated water containing iodine; total solids, 844 grs. per gal.

Motuhora (Whale Island), Bay of Plenty.—J. A. Pond. Transactions New Zealand Institute, vol. XI, p. 512.

Acid alum water.—Temperature, 198° F.; Total solids, 250·3 grs. per gal.; sodium sulphate, 17·60; calcium sulphate, 7·52; magnesium sulphate, 5·00; aluminium sulphate, 48·48; ferrous sulphate, 9·38; sulphuric acid (free), 138·32; silica, 24·0.

Mahurangu, Auckland.—J. Hector. Transactions New Zealand Institute, vol. I, p. 70, W. Skey; *Ibid.* vol. x, p. 424.

Chlorinated saline waters, reported as a specific for rheumatism.

(*a*) Cold spring temperature, 110° F. Total solids, 74 grs. per gal.; chlorine, 22·4; sulphuric acid, 8·80; calcium oxide, 5·2; magnesium oxide, 9·2; potassium oxide, 3·20; silica, 3·20; sodium oxide and carbonic acid, 20·40 (undetermined).

(*b*) Hot spring temperature, 140 F. Total solids, 140·4; sodium chloride, 85·2; calcium chloride, 16·8; magnesium chloride, 22·0; silica, 3·60; with trace of potash, carbonic acid, and sulphuric acid.

(*c*) Hot spring temperature, 141·6. Total solids, 141·6 grs. per gal., apparently of the same composition as (*b*).

Makaraka, Poverty Bay.—W. Skey. Colonial Museum and Laboratory Report XXI, p. 52.

Chalybeate water from artesian well.—Total solids, 61·77 grs. per gal.; calcium chloride, 26·88; sodium chloride, 10·87; magnesium chloride, 4·41; sodium sulphate, 5·22; calcium carbonate, 3·14; carbonate and chloride of iron, 7·24; silica, 4·01. Becomes cloudy and deposits ferruginous sediment on standing.

Nukaka, Hawkes' Bay.—H. Hill. Transactions, New Zealand Institute, vol. XXVII, p. 478.

A chlorinated saline water, containing iodine. Temperature, 97°—116° F. Said to be a specific for rheumatism, lumbago, &c. Analysis (G. Gray) unpublished. Total solids, 1,852·9 grs. per gal.; sodium chloride, 1,196·3; potassium chloride, 11·19; ferric chloride, 10·5; calcium chloride, 462·0; magnesium chloride, 26·6; silica, 19·6.

Napier, East coast of.—W. Skey. XXVIIIth Colonial Museum and Laboratory Report, p. 23.

Chlorinated water; feeble alkaline reaction. Total solids, 336 grs. per gal.; principally sodium chloride, with small quantities of lime and sulphuric acid; iodine present in notable quantity.

Napier, McLean's Run.—W. Skey. IXth Colonial Museum and Laboratory Report, p. 25.

Chlorinated alkaline water; reaction slightly alkaline. Total solids, 445·51 grs. per gal.; sodium chloride, 392·59; potassium

chloride, 4·44; sodium sulphate, 1·26; sodium carbonate, 18·60; magnesium carbonate, 15·83; calcium carbonate, 3·96; carbonate of iron, 2·38; silica, 6·41. Contains both iodine and bromine.

Ohaeawai, Auckland.—J. Hector. New Zealand Official Year Book, 1896, p. 426.

Acid aluminous water.—Temperature 60°—116° F. Total solids, 134·4; deposits sulphur and alum on cooling. Mercury in form of vapour is given off, which deposits cinnabar and metallic mercury.

Ohura.—W. Skey. XXth Colonial Museum and Laboratory Report, p. 52.

Chlorinated chalybeate water.—Total solids, 578·66 grs. per gal.; sodium chloride, 493·32; potassium chloride, 4·20; calcium chloride, 55·96; magnesium chloride, 1·84; magnesium iodide, ·62; calcium sulphate, 2·04; ferrous carbonate, 10·21; magnesium carbonate, 5·40; silica, 5·07.

Onekiniki.—W. Skey. XXIXth Colonial Museum and Laboratory Report, p. 19.

Chlorinated saline water.—Total solids, 198·95 grs. per gal.; sodium chloride (with a little potassium chloride), 155·78; magnesium chloride, 1·14; magnesium iodide, traces; sodium sulphate, 14·26; calcium sulphate, 3·47; sodium carbonate, 12·76; calcium carbonate, 1·19; iron and alumina, ·21; silica, 10·14; sulphuretted hydrogen, ·34 grs. per gal.

Onetapu Desert, Auckland (Wangaehu River).—W. Skey. Transactions, New Zealand Institute, vol. I, p. 28; *Ibid.*, vol. X, p. 424.

Alum water, with acid reaction.—Total solids, 456 grs. per gal., mainly potash alum, and magnesium, and ferrous chlorides.

Otira Gorge.—G. Gray. Transactions, New Zealand Institute, vol. XXII, p. 495.

Sulphuretted and siliceous water.—Specific gravity at 60° F. 1·00022; temperature, 87° F. (air, 61° F.); Total solids, 12·46 grs. per gal.; potassium sulphate, ·33; sodium sulphate, 3·99; sodium chloride, ·40; sodium sulphide, ·45; sodium silicate, 4·26; calcium silicate, ·34; calcium carbonate, 1·14; magnesium carbonate, ·29; alumina, ·21; free silica anhydride, 1·05; iodine, bromine, and lithium absent.

Pahua, Wairarapa E.—W. Skey. Transactions, New Zealand Institute, vol. x, p. 444; XIIth Colonial Museum and Laboratory Report, p. 45.

Chlorinated saline water, containing free iodine; reaction distinctly alkaline.—Total solids, 1,474·09 grs. per gal.; sodium chloride, 1,303·32; potassium chloride, ·50; magnesium chloride, 34·96; calcium chloride, 120·88; magnesium iodide, ·58; magnesium bromide, traces; calcium sulphate, 3·02; aluminium phosphate, ·64; calcium phosphate; ·43; calcium bi-carbonate, 6·45; silica, 1·69; iodine free, 1·59. A very characteristic water from the amount of free iodine it contains.

Pakaututu, Napier.—W. Skey. XXIXth Colonial Museum and Laboratory Report, p. 19.

Two waters, containing respectively 20·12 and 14·3 grs. per gal. of sodium chloride, with sulphuretted hydrogen and iodine in sensible quantities.

Papawhaniki, near Gisborne.—W. Skey. XXIVth Colonial Museum and Laboratory Report, p. 41.

A chlorinated saline water, feeble alkaline reaction.

Total solids, 764·5 grs. per gal., principally sodium chloride; iodine, 3·69 grs. per gal.

Puriri, Hikutaia, Auckland.—W. Skey. Transactions, New Zealand Institute, vol. x, p. 425. XVth Colonial Museum and Laboratory Report, p. 45.

Alkaline water.—Specific gravity, 1·006; total solids, 537·11 grs. per gal.; sodium chloride, 21·93; sodium sulphate, ·94; potassium sulphate, 4·93; calcium bi-carbonate, 28·50; magnesium bi-carbonate, 25·62; sodium bi-carbonate, 452·39; silica, 2·77. Traces of magnesium iodide, ferrous carbonate, and lithia.

This water is highly ærated with carbonic acid, and effervesces strongly when escaping from the spring.

A second analysis, 1880, showed but little change in the nature of the salts present, but that the water had become more concentrated. Total solids, 825·10 grs. per gal.

Rotorua District.—J. Hector. New Zealand Official Year Book, 1896, p. 429. A. Ginders, *ibid.*, p. 433.

See analyses, p. 100.

Taupo.—W. Skey. XVIIIth Colonial Museum and Laboratory Report, p. 55, *ibid*, XXth, p. 48.

See tables of analyses II, III, and IV, pages 102–4.

Te Aroha.—J. Hector. New Zealand Official Year Book, 1896, p. 427. XXIIIrd Colonial Museum and Laboratory Report, p. 70.

Alkaline carbonated waters, highly charged with carbonic acid. Traces of lithia present. Similar and equal in strength to the waters of Vichy and Chaudesargues, in France; Bilin, Bohemia; and Ems, Nassau.

Analyses (see table V, page 105.)

No. 2 is noted for relieving rheumatism.

No. 8 affords relief in cases of dyspepsia.

No. 17 is used as an eyewash, and contains 1·4 grs. of sulphuretted hydrogen per gal.

No. 16. An acid water containing sulphuretted hydrogen, 1·91 grs. per gal.

Total solids, 11·35 grs. per gal. Sodium sulphate, 1·82; calcium sulphate, ·61; magnesium sulphate, ·36; alumina and iron sulphates, ·20; silica, 7·04; free hydrochloric acid, 1·11; free sulphuric acid, ·21.

Te Aute.—W. Skey. XXVIth Colonial Museum and Laboratory Report, p. 37.

A chlorinated water containing 342·42 grs. per gal. total solids, including magnesium iodide, equivalent to 1·76 grs. of iodine per gal.

Tologo Bay.—W. Skey. XVIth Colonial Museum and Laboratory Report, p. 47.

Chlorinated water.—Reaction slightly alkaline. Total solids, 754·19 grs. per gal.; sodium chloride, 683·56 (with a little potassium chloride); magnesium iodide, 1·11; sodium sulphate, 5·75; sodium bi-carbonate, 12·96; calcium bi-carbonate, 28·14; magnesium bi-carbonate, 17·28; alumina (with trace of iron), 2·15; silica, 3·24; free iodine, trace.

Waikato.—Spring near Lake Whangape, west of Waikato River. J. Hector. Transactions New Zealand Institute, vol. I, p. 71.

Alkaline water.—Temperature, 160–200° F. Total solids, 47·04 grs. per gal., consisting mainly of alkaline chlorides; the remainder calcium silicate and alkaline carbonates.

Waimate Block.—W. Skey. XVIIIth Colonial Museum and Laboratory Report, p. 54.

Three chlorinated waters, distinct alkaline reaction and yellow colour.

Analyses.

	Grains per gallon.		
	1.	2.	3.
Sodium (a little potassium)	147·43	192·08	269·51
Lime	23·52	25·48	25·48
Magnesia	·99	5·91	2·61
Alumina	trace	2·86	trace
Iron oxides	2·94	trace	2·25
Chlorine	190·12	335·12	524·30
Iodine	·34	1·98	·99
Sulphuric acid	1·82	·66	1·34
Silica	·89	22·54	7·84
	368·05	586·63	834·32

Waipio, Poverty Bay.—W. Skey. XVIIth Colonial Museum and Laboratory Report, p. 54.

Chlorinated water; feeble alkaline reaction. Total solids, 705·03 grains per gal.; sodium chloride (potassium chloride a little), 593·41; calcium chloride, 82·20; magnesium iodide, ·76; calcium sulphate, 8·14; magnesium sulphate, 5·44; magnesium carbonate, 3·36; iron oxides, 5·84; silica, 5·88.

Wairarapa East.—W. Skey. XVth Colonial Museum and Laboratory Report, p. 43.

A chlorinated water containing 267·2 grs. per gal. including iodine, to the extent of a little above 1 gr. per gal.

Wairongoa.—North Taiera, Otago. A. G. Kidson Hunter, New Zealand Official Year Book, 1896, p. 435.

A weak chalybeate water containing free carbonic acid. Total solids, 14·00 grs. per gal.; sodium carbonate, 2·22; sodium chloride, 2·35; potassium chloride, ·31; calcium sulphate, 2·38; calcium carbonate, 1·82; magnesium carbonate; 1·00; ferrous carbonate, ·18; silica, 3·22; alumina ·25.

Waiwera, Auckland.—W. Skey. Transactions, New Zealand Institute, Vol. X, p. 429.

Alkaline saline water.—Temperature 110° F. Total solids, 219·49 grs. per gal.; sodium chloride, 116·71; potassium chloride, ·09; sodium sulphate. ·38; sodium bi-carbonate, 87·51; calcium bicarbonate, 10·69; magnesium bicarbonate, ·95; iron bicarbonate, ·68; silica, 2·46. Lithium, alumina, and magnesium iodide, traces.

Said to be beneficial in cases of rheumatism, scrofula, and gout.

Wallingford Wellington.—W. Skey. Transactions, New Zealand Institute, Vol. X, p. 444.

Chlorinated water containing 826 grs. per gal. total solids, consisting of alkaline and earthy chlorides with traces of bromides and iodides. Faintly acid reaction.

Wanganui.—W. Skey. XXIInd Colonial Museum and Laboratory Report, p. 57.

Chlorinated waters containing iodine, feeble alkaline reaction.

(a) From the right bank, Wanganui River, near Papaite. Total solids, 384·54 grs. per gal.; sodium chloride, 313·41; sodium sulphate, 3·20; calcium chloride, 11·69; magnesium chloride, 2·13; magnesium carbonate, 3·17; aluminium chloride, ·91; iron chloride trace, silica, 4·03.

(*b*) From a warm spring on the left bank of the Wanganui River, opposite Whakapoko, 2 miles above Pipiriki. Total solids, 130·61 grs. per gal.; sodium chloride, 121·88; calcium sulphate, 1·88; aluminium chloride, 1·22; sodium carbonate, ·48; calcium carbonate, ·52; magnesium carbonate, 2·22; silica, 2.14.

(*c*) From a spring 2 miles above Pipiriki, on the right bank of the Wanganui River. Total solids, 244·03 grs. per gal.; sodium chloride, 231·64; calcium sulphate, 3·19; aluminium chloride, ·21; sodium carbonate, ·83; calcium carbonate, 1·01; magnesium carbonate, 3·16; silica, 3·99.

Wellington, Northern Boundary of.—W. Skey. Transactions, New Zealand Institute, Vol. X, p. 446.

Chlorinated alkaline and chalybeate water.—Total solids, 444·71; sodium chloride, 392·59; potassium chloride, 4·44,; sodium sulphate, 1·26; sodium carbonate, 18·60; magnesium carbonate, 15·03; calcium carbonate, 3·96; iron carbonate, 2·38; silica, 6·41. Contains traces of bromine and iodine.

Whangarei.—J. A. Pond. Transactions, New Zealand Institute, Vol. XI, p. 512. W. Skey. XIIIth Colonial Museum and Laboratory Report, p. 32.

Carbonated alkaline water, highly charged with carbonic acid. Resembles the mineral water of Vichy in France.—Total solids, 216·17 grs. per gal.; sodium chloride, 43·67; potassium chloride, traces; sodium sulphate, 1·63; sodium bi-carbonate, 58·25; calcium bi-carbonate, 90·67; magnesium bi-carbonate, 4·39; iron bi-carbonate, 3·75; silica, 13·81; aluminium phosphate, traces.

Whareama, Masterton.—W. Skey. XXIIIrd Colonial Museum and Laboratory Report, p. 69.

A sulphuretted chlorinated water, containing 316·36 grs. per gal. total solids. Iodine, combined, ·81; sulphuretted hydrogen, 1·76.

White Island or Whakaari.—J. Hector. Transactions, New Zealand Institute, Vol. III, p. 282.

Acid waters.

(1) Lake.—Specific gravity, 1·088. Total solids, 13,638·1 grs. per gal.; ferrous sulphate, 1059·8; sodium sulphate, 658·7; potassium sulphate, 275·8; calcium sulphate, 235·9; magnesium sulphate, 60·2; aluminium sulphate, 80·5; aluminium sesqui chloride, 1703·1; silica, 21·7; hydrochloric acid (free), 9541·7.

(2) Fumerole.—Specific gravity, 1·003. Total solids, 205·80 grs. per gal.; calcium sulphate, 11·62; sodium sulphate, ·63; magnesium sulphate, 2·94; ferrous sulphate, 2·38; silicic acid, ·91; sulphuric acid (free), 1·12; hydrochloric acid (free), ·98; ammonia; sulphurous, and phosphoric acids, traces.

Wickliffe Bay, Otago.—Black J. G. New Zealand Official Year Book, 1896, p. 434.

Alkaline saline water.—Total solids, 276·7 grs. per gal. Alkalies, 83·0; lime, 11·5; magnesia, 18·3; sulphuric acid (combined), 39·3; chlorine, 112·0; carbonic acid (combined), 12·6.

SOUTH AUSTRALIA.

Communicated by J. W. Jones, Conservator of Water. Analyses by G. A. Goyder, F.C.S.

Waters from the Central Australian Secondary Artesian Basin. (Table VI, page 106.)

WESTERN AUSTRALIA.

Kalgoorlie and Coolgardie.—Communicated by F. S. Earp, Ph.D., F.C.S.

(Table of analyses, VII, page 108.)

NEW SOUTH WALES.

Bungonia.—Rev. J. Milne Curran, Proceedings, Royal Society, New South Wales, vol. XXVIII, 1894, p. 54.

A carbonated alkaline water.—Total solids, 103·18; calcium carbonate, 61·10; magnesium carbonate, 10·83; ferrous carbonate, ·30; sodium carbonate, ·80; potassium carbonate, 6·26; sodium chloride, 9·68; calcium sulphate, 1·97; silica, 1·47. Contains free carbonic acid gas.

Ballimore.—J. C. H. Mingaye. IVth Report, Australasian Association, 1892, p. 277, and Proceedings, Royal Society, New South Wales, vol. XXVII, pp. 115 and 102.

An alkaline water, highly charged with carbonic acid gas.—Specific gravity at 65° F. 1·00359. Total solids, 224·62 grs. per gal.; sodium bicarbonate, 183·10; potassium bicarbonate, 12·82; lithium bicarbonate, ·05; calcium bicarbonate, 11·38; magnesium bicarbonate, 9·36; strontium bicarbonate, trace; iron bicarbonate, ·70; sodium chloride, 6·92; alumina, trace; silica, ·28.

Jarvisfield, Picton.—A. J. Sach. IVth Report, Australasian Association, 1892, p. 272, J. C. H. Mingaye; *Ibid.*, p. 279, and Proc. Royal Society, New South Wales, vol. XXVI, 1892, p. 102.

Total solids, 182·56 grs. per gal.; magnesium bicarbonate, 31·22; calcium bicarbonate, 11·13; sodium chloride (with a little potassium), 120·00; magnesium sulphate and chloride, 11·13; silica, ·33; calcium sulphate, ·67; sodium nitrate, ·28 (Sach).

Milparinka.—Communicated by A. H. Jackson, B.Sc., F.C.S., Melbourne.

Contains chlorides and sulphates of iron, lime, magnesium, sodium, and a little alumina; reaction acid; strongly constipative. Horses and dogs will not drink the water unless perishing by thirst.

Mittagong.—J. C. H. Mingaye. Proceedings, Royal Society, New South Wales, vol. XXVI, 1892, p. 101.

Chalybeate water, containing free carbonic acid gas.—Total solids, 15·76 grs. per gal.; iron bicarbonate, 5·98; magnesium bicarbonate, 2·24; calcium bicarbonate, 2·04; sodium chloride, 2·15; potassium chloride, 2·04; magnesium chloride, 1·29.

Narrandara.—Communicated by A. H. Jackson, B.Sc., F.C.S., Melbourne.

Total solids, 256·4 grs. per gal.; sodium chloride, 132·4; sodium sulphate, 93·72; magnesium sulphate 49·2; calcium carbonate, 74·8; iron and alumina, 2·74; silica, &c., 3·94 reaction alkaline.

Rocky Flat, near Cooma (Monara district).—J. C. H. Mingaye. Proceedings, Royal Society, New South Wales, vol. XXVI, p. 103.

Alkaline water.—Total solids, 142·52 grs. per gallon; sodium bicarbonate, 45·29; potassium bicarbonate, 17·15; calcium bicarbonate, 52·08; magnesium bicarbonate, 22·40; strontium bicarbonate, strong trace; sodium chloride, 5·04; silica, 56; highly charged with carbonic acid gas.

VICTORIA.

Castlemaine.—Communicated by A. H. Jackson, B.Sc., F.C.S., Melbourne.

Total solids, 163 grs. per gallon; sodium chloride, 101·05; sodium sulphate, 17·5; sodium nitrate, 3·7; sodium carbonate, 5·4; magnesium carbonate, 11·1; calcium carbonate, 18·6; iron and alumina, 4·25; silica, 1·4; reaction alkaline.

Corangamite Lake.—A. W. Craig and N. T. M. Wilsmore. IVth Report, Australasian Association, 1884, p. 270.

Total solids, 3222·7 grs. per gallon. Calcium, 4·41; magnesium, 89·04; potassium, 27·09; sodium, 1130·15; sulphuric acid, 53·06; chlorine, 1911·84; bromine, 7·14; contains free sulphuretted hydrogen, carbonic acid, and lithium.

QUEENSLAND.

Communicated by R. L. Jack, F.G.S., F.R.S., Government Geologist of Queensland.

Charleville (Artesian Bore.)—Water said to possess curative properties in cases of ophthalmia, rheumatism, ulcerated sores, &c.

Helidon (Smith's Well).—Report of J. B. Henderson, Hydraulic Engineer, 1896, p. 114.

Chlorinated and carbonated water.—Total solids, 1027·6 grs. per gallon; sodium chloride, 578·0; magnesium carbonate, 205·0; calcium carbonate, 88·0; iron oxide, 10·0.

I.—Mineral Waters of

Results expressed in grains per gallon.

Name of Spring.	Temperature, F.	Sulphate of Sodium.	Sulphate of Potassium.	Sulphate of Calcium.	Sulphate of Magnesium.	Sulphate of Aluminium.	Sulphate of Iron.
	° °						
Te Pupunitanga, Priest's Bath	94–110	19·24	trace	7·41	3·03	21·67	1·24
Waikupapapa, Saddler's Bath	120	33·18	·26	2·44	·24	·32	trace
Waikirihou, Vaux's Bath	112	32·87	1·24	4·93	1·83	33·22	4·42
Ngaruapuia, Gemini Bath	108	29·80	·64	6·87	·31	..	trace
Toko, Postmaster's Bath	120	45·09	·41	2·45	·30	1·34	·71
Arikikapakapa	160	12·51	·38	2·21	1·29	·68	3 15
Te Mimi Okakahi	90–112	4·78	·13	2·04	·93	trace	·23
Ti Kute, Great Spring	160–212	12·66	·59	1·01	·69	11·22	1·73
Sulphur Bay Spring	90–100	8·37	·07	2·50	·93	trace	2·68
Perekari	130–150	26·75	..	2·45	1·86	trace	·76
Whangapipiro, Mme. Rachel's Bath	170–210	1·53	..	..	..	..	..
Oruawhata	140	..	..	5·48	..	..	..
Hinemaru, Stonewall Jackson	98–118	2·76	..	..	..	..	..
Matuatonga, Corlett's Bath	172	..	..	10·32	..	..	..
Whakarewarewa, Tuikore	96–120	13·47	..	..	..	..	..
,, Koroteoteo	212	7·49	..	..	..	..	..
Rotoiti Manupirua	....	11·50	..	2·43	..	..	..
Kuirau	136–156	10·31	..	..	..	..	..
Tapui Te Koutu	90–108	7·06	..	..	..	..	..
Te Kawoanga, Cameron's	109–15	44·54	..	..	..	..	..
,, Pain Killer	204	29·14	..	..	..	..	..
,, Coffee Pot	80–100	23·71	..	..	..	..	..

the Rotorua District.

Analyst, W. Skey, F.C.S.

Free Sulphuric Acid.	Free Hydrochlorine Acid.	Silica.	Potassium Chloride.	Sodium Chloride.	Lithium Chloride.	Sodium Silicate.	Calcium Silicate.	Magnesium Silicate.	Iron and Alumina.	Calcium Chloride.	Magnesium Chloride.	Total Solids.	Sulphuretted Hydrogen.	Carbonic Acid Gas.
22·12	3·65	18·41	..	..	..	..	..	..	....	..	..	96·77	2·98	2·16
4·29	7·49	8·23	..	..	..	..	..	..	....	..	..	56·45	3·61	..
30·32	6·14	17·61	..	..	..	..	..	..	....	..	..	132·58	3·02	..
3·11	6·76	12·01	..	..	..	..	..	..	....	..	..	59·50	trace	..
17·86	7·40	10·10	..	..	..	..	..	..	....	..	..	85·67	5·6	..
13·95	2·62	18·15	..	..	..	..	..	..	....	..	..	54·94	..	..
12·48	3·82	4·12	..	..	..	..	..	..	....	..	..	29·51	·98	..
·77	1·63	12·40	..	..	..	..	..	..	....	..	..	48·44	5·74	..
18·02	·86	10·08	..	..	..	..	..	..	....	..	..	44·52	1·01	..
..	5·38	18·17	·63	..	..	..	..	..	....	..	..	56·00	..	..
..	..	18·21	3·41	69·43	trace	31·02	4·24	1·09	2·41	..	..	131·34	..	3·7
..	..	14·20	..	60·44	..	8·38	..	·32	1·42	..	1·04	91·28	5·52	..
..	..	8·29	4·69	93·46	trace	6·41	2·89	1·02	2·10	..	..	121·62	..	..
..	..	..	..	66·44	..	29·27	..	..	....	6·72	·31	113·27	2·21	..
..	..	..	1·24	53·61	..	16·32	1·61	1·14	·39	..	..	87·78	..	..
..	..	..	1·46	66·34	trace	2·08	3·16	·76	·85	..	..	104·54	..	..
..	..	8·53	·47	6·25	..	..	1·51	·77	·99	..	..	32·45	..	..
..	..	18·42	2·08	45·70	..	2·57	·34	·12	·31	..	..	79·85	..	..
..	..	5·55	·97	29·94	..	32·12	1·62	·40	·67	..	..	78·33	..	..
..	5·92	9·22	1·67	12·04	..	..	..	..	·62 Chlorides.	5·22	1·28	80·51	4·42	..
..	6·84	18·02	1·71	46·42	..	..	..	..	4·22	2·66	1·47	110·48	4·84	..
7·60	7·66	13·86	·77	..	..	..	..	..	2·93	2·04	1·62	60·19	3·19	..

II.—Taupo Mineral Waters (1), Lofley's Baths.

Results expressed in grains per gallon. Analyst, W. Skey, F.C.S.

No.	Locality and Spring.	Temperature Fah.	Chloride of Sodium.	Chloride of Potassium.	Chloride of Calcium.	Chloride of Magnesium.	Chloride of Iron and Alumina.	Sulphate of Sodium.	Sulphate of Calcium.	Sulphate of Iron and Alumina.	Silicate of Soda.	Silicate of Calcium.	Silicate of Magnesium.	Hydrochloric Acid.	Silica.	Total Solids in Grains per Gallon.	Sulphuretted Hydrogen.
		° F															
1	Rotokawa, Black Water	192	59·66	2·61	15·69	1·09	·33	26·16	..	..	..	..	..	18·47	19·21	142·92	3·98
2	,, Yellow Water	152	22·08	·70	9·75	1·20	..	16·33	..	..	..	..	..	104·15	22·04	176·25	5·84
3	Wairakei, White Water	112	·83	trace	..	..	..	6·45	..	trace	5·73	1·12	·63	....	·12	14·88	..
4	Ruahine, Crow's Nest	180	135·81	3·14	..	..	..	·71	..	1·10	4·71	1·48	·69	....	6·21	153·85	..
5	,, Witches' Cauldron	192	138·26	3·01	..	..	..	1·34	..	1·16	2·91	4·60	·91	....	14·16	166·35	..
6	,, Ohinekahoro	195	161·69	2·96	..	..	..	·71	..	·99	1·84	6·92	2·87	....	6·27	184·25	..
7	,, Spring on Flat	132	1·01	trace	..	..	..	1·02	..	trace	3·24	4·42	1·39	....	8·14	18·22	..
8	Ohunahike, Acacia	136	6·94	trace	..	..	..	4·99	1·28	·84	..	2·61	1·81	....	12·82	31·29	..
9	Lofley's, McPherson's	96	3·82	trace	..	..	..	2·61	·07	trace	..	1·49	1·06	....	6·18	15·23	..
10	,, Cold Stream	76	2·76	trace	..	..	..	..	2·01	trace	..	·46	2·64	....	3·01	10·88	..
11	,, Warm Spring	114	1·51	trace	..	..	..	8·89	..	·47	trace	3·64	1·62	....	6·64	22·77	..
12	,, Sumach	106	1·61	trace	..	..	..	8·62	..	·30	·41	2·96	1·24	....	9·42	24·56	..
13	,, Source No. 1	106	4·03	...	..	..	..	3·69	·11	·43	...	4·71	1·48	....	10·10	24·55	..
14	,, ,, No. 2	136	129·06	2·99	..	..	..	9·02	..	trace	1·08	3·89	3·02	....	3·68	152·74	..
15	Kokowai	104	·61	..	..	..	..	2·35	..	·72	6·06	2·99	1·62	....	2·10	16·45	..
16	Waipahihi, A.C. Bath No. 1	..	8·01	trace	..	..	..	·93	7·22	·66	·69	5·64	2·49	....	12·64	38·28	..
17	,, ,, No. 2	..	14·03	trace	..	..	..	7·82	7·10	trace	..	1·46	1·78	....	13·73	45·92	..
18	,, Tea-tree Spring	..	86·26	2·06	..	..	..	·63	2·10	trace	·41	..	·49	....	15·99	107·94	..
19	,, Source No. 1	98 170	54·61	1·91	..	..	..	6·56	..	1·28	3·01	1·69	1·26	....	16·11	86·43	..
20	,, ,, No. 2	..	66·46	1·84	..	..	..	6·81	..	·81	·67	4·22	·96	....	22·63	104·40	..
21	,, Stream	..	45·81	1·49	..	..	..	3·92	..	2·16	1·81	4·69	·89	....	8·01	68·78	..
22	Wairiki, Waikato	125	51·91	1·98	8·92	..	..	2·06	..	2·46	..	2·69	·84	....	16·19	87·05	..

III.—Taupo Mineral Waters (2), Wairakei.

Results expressed in grains per gallon. Analyst, W. Skey, F.C.S.

No.	Locality and Spring.	Temperature, Fah.	Chloride of Sodium.	Chloride of Potassium.	Chloride of Calcium.	Chloride of Magnesium.	Chloride of Iron and Alumina.	Sulphate of Sodium.	Sulphate of Calcium.	Sulphate of Iron and Alumina.	Silicate of Sodium.	Silicate of Calcium.	Silicate of Magnesium.	Hydrochloric Acid.	Silica.	Total Solids in Grains per Gallon.	Sulphuretted Hydrogen.
1	Ketitani Tongariro, Main Stream..	..	2·82	trace	..	..	..	8·24	8·87	12·82	..	..	..	·46	14·24	48·43	..
2	,, Meeting of Waters	..	3·14	·29	..	..	..	9·99	13·61	11·48	..	..	..	·62	20·11	60·22	..
3	Waikato River, Matana Kutai	92–104	8·01	trace	12·91	·46	·04	1·26	..	..	..	1·46	2·62	..	8·04	34·82	..
4	Wairakei, Kiriohinekai	108	2·79	trace	9·14	..	2·29	11·61	..	..	..	1 24	2·14	..	9·01	39·22	..
5	,, Steam Hammer Geyser	212	174·60	7·12	7·14	1·95	·29	6·91	..	..	..	2·71	1·84	..	15·64	217·20	..
6	,, North side Cream......	160	171·97	6·94	6·11	2·42	trace	7·41	..	..	..	1·99	1·71	..	16·19	214·74	..
7	,, White	200	5·81	trace	·71	·44	trace	4·02	2·80	..	..	..	..	..	14·71	28·49	..
8	,, ,, Pink	180	110·43	10·14	5·62	1·84	trace	14·24	..	..	..	1·20	2·16	..	12·48	158·11	..
9	,, South side Great Geyser	212	119·27	6·23	9·64	2·22	trace	5·20	..	..	..	1·24	1·70	..	16·45	162·02	..
10	,, ,, Near Geyser	210	170·00	14·21	11·01	3·01	·22	8·14	..	..	..	1·36	1·60	..	18·01	227·75	..
11	,, Black Pool	210	120·02	6·19	11·14	1·84	·14	6·29	..	..	..	2·46	1·14	..	18·89	168·11	..
12	,, Little Champagne	178	11·08	·64	1·67	·21	trace	3·22	..	..	..	..	..	·11	1·20	18·13	..
13	,, Champagne Pool	212	195·20	16·17	13·14	2·46	..	3·21	..	..	..	1·41	2·62	..	21·64	258·88	..

IV.—Taupo Mineral Waters (3), Tokaanu.

Results expressed in grains per gallon. Analyst, W. Skey, F.C.S.

No.	Locality and Spring.	Temperature, Fah.	Chloride of Sodium.	Chloride of Potassium.	Chloride of Calcium.	Chloride of Magnesium.	Chloride of Iron and Alumina.	Sulphate of Sodium.	Sulphate of Calcium.	Sulphate of Iron and Alumina.	Silicate of Sodium.	Silicate of Calcium.	Silicate of Magnesium.	Hydrochloric Acid.	Silica.	Total Solids in Grains per Gallon.	Sulphuretted Hydrogen.
1	Teretere	140	301·17	14·92	11·15	1·01	5·21	4·26	..	..	..	2·81	3·29	..	18·27	362·09	..
2	Tohuriri	94	290·14	10·11	10·17	1·64	3·18	4·14	..	..	..	2·60	2·73	..	17·18	341·89	..
3	Piri	182	281·63	9·22	8·98	2·14	3·04	4·01	..	..	..	2·84	2·17	..	18·16	332·19	..
4	Mill Spring	122	371·27	14·29	14·97	4·26	2·69	3·17	..	..	..	2·61	1·99	..	17·14	432·30	..
5	Petrifying Spring	156-192	468·14	18·17	13·80	4·96	2·71	4·80	..	..	..	3·81	3·78	..	24·81	544·91	..
6	Teretiti	162	200·67	10·16	6·71	1·47	trace	2·41	..	..	..	2·60	2·88	..	28·17	250·07	..
7	Raupo Spring	140	201·73	9·29	6·09	1·61	trace	2·67	..	..	..	·71	2·71	..	24·19	251·00	..
8	Paurini Spring	152	396·11	11·47	16·19	2·67	2·98	4·99	..	..	..	4·99	3·94	..	24·10	467·44	..
9	To Korokoro te Poinga	208-212	394·20	12·16	15·95	4·19	9·64	1·91	..	..	..	5·17	3·68	..	24·94	471·84	..
10	Teata Kokoriki	110	129·66	5·87	22·16	4·99	trace	2·84	..	..	..	2·61	2·21	..	12·94	183·28	..
11	Hurikareao	86	87·10	3·44	7·11	3·20	trace	1·71	..	..	..	·92	1·80	..	12·60	117·88	..
12	Tikotai	168	301·64	9·99	18·16	5·09	1·06	3·81	..	..	..	4·14	2·74	..	17·85	364·48	..
13	Pareruai	130	217·41	14·21	14·11	4·19	·91	2·99	..	..	..	2·74	1·99	..	14·11	272·66	..
14	Tauwhare	198	279·83	15·14	17·31	5·21	1·11	3·90	..	..	..	3·15	2·01	..	19·12	346·78	..
15	Rangitamaki	204	281·77	12·43	14·12	5·55	·87	4·27	..	..	..	3·07	1·74	..	18·10	341·92	..
16	Piroi	192	109·91	7·13	7·16	3·16	·61	3·12	..	..	..	2·11	1·41	..	19·17	153·7	..

V.—Te Aroha Mineral Waters.

Results expressed in grains per gallon. Analyst, W. Skey, F.C.S.

No.	Temp., F.	Total Mineral Solids.	Chloride of Sodium.	Chloride of Potassium	Sulphate of Soda.	Carbonate of Lime.	Carbonate of Magnesia.	Carbonate of Soda.	Alumina.	Iron Oxide.	Silica.	
1	102	586·99	60·52	1·72	38·32	10·77	6·86	461·56	Traces..	Traces..	7·56	1–15, and 18 clear, marked saline and feebly caustic taste. All are colourless, with the exception of 4, 13, and 14, which are pale yellow. No. 17 turbed from the presence of precipitated sulphur.
2	112	539·76	60·45	1·90	32·67	7·12	4·21	426·29	,,	,,	7·12	
3	112	541·17	60·51	Included with chloride of sodium.	32·82	7·24	4·20	429·19	,,	,,	7·21	
4	92	311·82	34·24		19·16	4·62	2·14	246·49	,,	,,	5·17	
5	100	598·43	68·77		36·92	6·91	3·15	476·58	,,	,,	6·10	
6	104	618·37	66·23		35·14	7·12	2·99	499·75	,,	,,	7·14	
7	86	564·18	67·13		34·04	7·46	4·34	444·20	,,	,,	7·01	
8	109	573·26	66·14	1·96	32·91	7·47	4·21	451·97	,,	,,	8·60	
9	112	378·61	41·29	......	22·16	4·94	2·61	301·17	,,	,,	6·44	
10	96	343·60	35·24	......	19·19	4·67	2·31	276·19	,,	,,	6·00	
11	88	330·03	34·69	......	20·12	5·11	2·56	261·44	,,	,,	6·11	
12	88	380·81	41·66	Included with chloride of sodium.	22·96	5·12	2·99	300·97	,,	,,	7·11	
13	120	380·27	40·67		21·86	6·11	3·13	301·64	,,	,,	6·86	
14	122	404·70	42·61		23·16	7·14	3·49	321·64	,,	,,	6·66	
15	139	414·60	43·11		22·16	6·91	3·61	331·76	,,	,,	7·05	
16	......	....	......		......	......	......	....	,,	,,	......	
17	cold	21·11	2·71	......	3·92	·64	·27	9·36	,,	,,	4·21	
18	cold	172·12	16·12	......	8·16	1·97	1·01	131·72	,,	,,	13·14	

VI.—Waters from

Results expressed in grains per gallon.

	Name of Spring.	Sodium Chloride.	Potassium Chloride.	Magnesium Chloride.	Sodium Sulphate.	Calcium Sulphate.	Magnesium Sulphate.	Lithium Sulphate.
1	Strangways Springs	329·71	7·30	....	16·88	18·09	18·55	....
2	Bopeechee Springs	97·06	3·05	....	13·34	....	....	....
3	Mount Hamilton Spring.........	223·77	4·20	....	37·81	....	....	....
4	Coward Bore Hole	172·24	2·90	....	19·63	....	....	....
5	Coward Spring	158·05	3·20	.....	20·59	....	....	....
6	Francis Spring	290·11	6·10	·59	....	36·17	24·54	....
7	Blanche Cup	215·28	4·10	....	15·47	....	....	....
8	Anna Creek Bore Hole	286·93	4·80	·27	....	35·02	22·61	....
9	Fred's Springs	59·16	1·60	....	2·38	....	....	....
10	Arcoeillinna	56·54	8·49	14·53	....	18·32	8·20	....
11	Indulkana	47·53	2·51	·83	....	....	16·43	....
12	Herrgott Springs	73·77	3·45	....	....	....	....	....
13	Shallow well, n'r Herrgott Sp's..	88·84	2·78	....	....	....	....	....
14	Mount Freeling................	46·55	·06	....	35·58	....	8·10	....
15	Catts Springs..................	195·56	1·58	....	84·15	....	....	....
16	Mr. Wyly's well at Farina	1,331·59	1·07	60·60	....	255·61	98·92	....
17	Well on Reserve near Farina....	265·08	·18	....	32·05	....	23·80	....
18	The Peake	124·19	3·30	....	48·56	....	8·40	....
19	Cadna-owie....................	96·87	2·30	....	41·90	....	2·55	....
20	Andrawilla, Eleanor River......	1·32	·90	....	·60	....	....	....
21	Healy Springs, Indulkana Sp'gs.	55·60	5·06	6·53	....	5·95	15·71	....
22	Oolarinna Soakage Well........	59·46	9·19	....	8·40	....	10·20	....
23	Billa-kalina Springs, Strangways	271·47	2·69	....	36·53	....	5·20	·24
24	Sulphur Spring, Strangways ..	320·86	5·92	....	34·89	18·70	10·80	·16
25	Nilpinna Spring	116·40	3·35	....	25·46	9·56	21·49	....
26	Weedina Spring	135·62	3·88	26·21	....	25·47	38·39	....
27	Lake Harry Bore	28·28	1·75	....	....	....	....	....
28	Kopperamanna Bore	17·50		....	....	....	trace	....
29	Codnadatta Bore	79·92		....	20·05	....	10·55	....
30	Hamilton Creek Bore	72·17		....	18·04	....	9·05	....
31	Coward Bore, 1 mile from No. 4.	168·41		....	18·76	....	....	....
32	Alton Downs, Herbert River, N. Territory.	15·44	·55	....	11·45	111·25	18·45	....

South Australia.

Analyst, G. A. Goyder, F.C.S.

Sodium Carbonate.	Sodium Bi-carbonate.	Calcium Carbonate.	Magnesium Carbonate.	Iron Carbonate.	Sodium Silicate.	Calcium Silicate.	Magnesium Silicate.	Aluminium Silicate.	Iron Silicate.	Sodium Nitrate.	Total dissolved Solids.
....	....	25·40	....	....	..	....	....	....	....	....	416·53
55·15	....	5·25	4·43	....	..	....	....	....	....	....	178·28
15·39	....	17·40	9·90	....	..	....	....	....	....	....	308·47
39·48	....	8·20	10·29	....	..	....	....	....	....	....	252·74
40·30	....	7·60	9·48	....	..	....	....	....	....	....	239·22
....	....	16·10	....	....	..	....	....	....	....	....	373,61
22·14	....	13·30	12·11	....	..	....	....	....	....	....	282·40
....	....	16·70	....	....	..	....	....	....	....	....	366·33
53·93	....	4·70	3·96	....	..	....	....	....	....	....	125·73
....	....	10·90	....	10·03	..	2·12	....	....	....	1·14	130·27
....	.. .	8·30	·19	....	..	6·38	....	....	....	1·00	83·23
70·63	....	1·55	2·03	....	..	1·45	....	....	3·49	·85	157·22
81·00	....	1·90	1·71	.. .	..	·25	....	....	2·58	1·20	180·26
....	....	13·59	8·40	....	..	2·70	....	....	....	1·70	116·68
....	....	20·10	13·61	·65	..	....	....	....	1·34	·57	317·56
....	....	17·40	....	....	..	1·23	....	·91	·30	·21	1,767·84
....	....	28·47	20·36	....	..	4·09	....	....	....	·49	374·92
....	....	14·80	5·12	....	..	2·20	....	·26	·03	·35	207·21
....	....	12·30	4·28	....	..	2·33	....	·31	·06	·60	163·50
7·08	....	Nil.	1·54	....	..	4·17	1·59	·42	·03	1·00	18·65
....	....	13·09	....	....	..	2·34	....	·10	.. ..	....	104·38
....	....	6·12	....	....	..	12·56	....	·25	·05	....	121·11
....	....	37·78	....	....	..	2·06	....	·45	·15	·90	366·15
....	....	35·00	....	....	..	1·27	....	·75	trace	1·12	429·47
....	....	21·80	....	....	..	1·88	....	·32	·27	1·14	201·67
....	....	25·04	....	....	..	1·83	....	·15	·10	·18	256·87
36·41	41·21	....	...	....	·72	1·42	·25	·30	·05	·12	110·51
49·04	....	trace	....	....	..	....	....	....	....	....	69·44
....	....	12·80	2·27	....	..	....	....	....	....	....	125·59
....	....	11·10	2·43	....	..	....	....	....	....	....	112·79
42·18	....	8·00	8·15	....	..	....	....	....	....	....	245·50
....	....	28·30	....	....	..	3·59	....	·68	·06	1·35	191·12

VII.—Analysis of Waters from West Australian Gold-fields (F. S. Earp, Ph. D., F.C.S.).

Results expressed in grains per gallon.

Locality.	Sodium Chloride.	Potassium Chloride.	Magnesium Chloride.	Calcium Sulphate.	Magnesium Sulphate.	Sodium Sulphate.	Calcium Carbonate.	Magnesium Carbonate.	Ferric and Aluminic Oxides.	Silica.	Organic Matter and Loss.	Total.
Hannan's Brown Hill Mine, 1895, Kalgoorlie	3010·0	trace	...	...	560·0	...	462·0	...	...	...	28·0	4060·0
Hannan's Brown Hill Mine, 1897, Kalgoorlie............................	2835·0	...	...	...	378·0	...	175·0	161·7	15·40	22·4	192·5	3780·0
Hannan's Brown Hill Water Shaft, 1896, Kalgoorlie	2520·0	trace	182·0	...	210·0	...	42·0	...	42·0	14·0	280·0	3290·0
Hannan's Brown Hill Extended Mine, 1897, Kalgoorlie	3276·0	...	...	95·2	336·0	...	90·3	...	26·6	16·1	132·3	3972·5
Hannan's Lake, 1895, Kalgoorlie ...	3745·0	98·0	567·0	. .	210·0	...	77·0	...	77·0	28·0	35·0	4837·0
Government Bore, Hannan's, 1895, Kalgoorlie..	6020·0	...	602·0	...	378·0	...	406·0	756·0	...	70·0	trace	8232·0
Ivanhoe Mine, Kalgoorlie, 1896	2499·0	...	...	154·0	420·0	...	...	...	35·0	...	...	3108·0
Coolgardie Mint Mine, Kalgoorlie, 1896	2212·0	...	469·0	238·0	...	196·0	...	...	21·0	...	...	3136·0
Golden Bar Mine, Coolgardie, 1895...	1386·0	trace	70·0	...	357·0	...	42·0	...	42·0	trace	105·0	2002·0
Croesus South United Mine, 1897, Kalgoorlie............................	2772·0	...	...	84·0	336·0	...	168·7	...	18·2	14·7	43·4	3437·0

No. 4.—ON THE OCCURRENCE OF GLACIAL BOULDERS AT YELLOW CLIFF, CROWN POINT STATION, FINKE VALLEY, CENTRAL AUSTRALIA.

Third Report of the Committee, consisting of Captain Hutton, F.R.S., Mr. R. L. Jack, F.G.S., F.R.G.S., Professor Tate, F.G.S., Mr. R. M. Johnston, F.G.S., Mr. G. Sweet, F.G.S., Mr. J. Stirling, Mr. W. Howchin, F.G.S., Mr. E. G. Hogg, M.A., Mr. E. J. Dunn, F.G.S., Mr. A. Montgomery, M.A., F.G.S., Mr. E. F. Pittman, Assoc. R.S.M., and Professor David, B.A., F.G.S. (Secretary).

EVIDENCES OF GLACIAL ACTION IN CENTRAL AUSTRALIA.

I. Introduction.

THE evidences herein described are supplied by a great number of pebbles unmistakably grooved and striated by ice, several of which are now exhibited.

The locality where the pebbles occur, Yellow Cliff, near Crown Point, in the Valley of the Finke, Central Australia, was visited by Professor Tate, in Company with Professor Baldwin Spencer, on the occasion of the Horn Expedition in 1894. They both observed then that some of the pebbles showed evidence of striation, though Professor Tate considered the evidence obtained at the time insufficient to justify the conclusion that the striation was ascribable to ice action, and consequently did not refer to this in the account of the locality published in the Geological Report of the Horn Expedition. Mr. J. A. Watt, M.A., B.Sc., also visited the locality, on the same expedition, and made the following entry in his field-book, which he has allowed us to copy :—

"Before reaching Crown Point a peculiar structure is seen in the small white and yellow kaolinised sandstone hills, the structure simulating contortion, and probably due to settling of partially consolidated material owing to the melting of ice."

The locality is described as follows by Professor Tate and Mr. Watt* :—

"Yellow Cliff, at the S.E. bend of the Finke, near Crown Point Head Station, which is about 50 feet high, consists o yellow and buff sandstone, strongly false-bedded near the top, intersected by vertical joints filled with limonite, enclosing pebbles of Desert Sandstone and quartzite ranging from small gravel to $2\frac{1}{2}$ by $4\frac{1}{2}$ inches, occasionally 2 feet cube, the pebbles are some-

* Rep. Horn Scientific Expedition to Central Australia. Part III. Geology and Botany, p. 72. London and Melbourne, March, 1896.

what rounded and smoothed, many of them are standing on edge. At the east end of this bluff the sandstone is very tumultuously bedded, and in its basal part contains a conglomerate of about 4 feet thick."

This formation is grouped (*op. cit.*) under the head of Tertiary river gravels.

Professor Baldwin Spencer, on the occasion of his second expedition to Central Australia during 1896, being anxious to obtain further evidence bearing on the possible glacial origin of the pebbles, revisited the locality in company with Mr. P. M. Byrne, and together they succeeded in obtaining important evidence which places the glacial origin of the striæ beyond dispute. They discovered at Yellow Cliff a large number of pebbles glacially grooved and striated, of which five specimens brought down and submitted by Professor Spencer and Mr. Byrne to the Glacial Committee are now exhibited.

II. Mode of Occurrence of the Glacial Pebbles.

The largest is 6 inches in diameter; they are all of quartzite, and of a reddish brown to brownish-grey colour. Four are rounded, and one sub-angular; three of them have lost their original upper surfaces through exfoliation. All exhibit glacial striæ more or less distinctly on their bottoms and sides. The smallest pebble has been ground down to a flat surface, and has been strongly striated and grooved by ice action. As regards their mode of occurrence, it is stated that the pebbles, from 1 inch to 1 foot in diameter, occur in a layer from 2 to 3 feet thick, imbedded in a sandy matrix overlying the soft, yellowish grey sandstone, already referred to in the foregoing description. Their level above the sea is about 1,000 feet. The general appearance of Yellow Cliff is shown on the accompanying plate. The glaciated pebbles may have weathered out of the sandy matrix in which they now occur.

III. Stratigraphical Relations.

At Crown Point, in the same neighbourhood, Professor Spencer and Mr. P. M. Byrne observed a formation which, judged on lithological grounds only (as no fossils were found), appeared to be identical with that underlying the stratum containing the glacial pebbles. Whereas, however, the "tumultuously-bedded" sandstone at Yellow Cliff has only a general low angle of dip of from 2° to 3°, it dips at Crown Point (if the above provisional lithological correlation be correct) at 73°. At Crown Point the steeply-dipping friable sandstone is unconformably capped by Desert Sandstone. Mr. J. A. Watt states that he considers that the friable sandstone, showing the tumultuous bedding at Yellow Cliff, is conformable to the Desert Sandstone, the age of the Desert Sandstone (*cf.* Tate and

Report of the Committee on Glacial Action in Central Australia.

YELLOW CLIFF FINKE VALLEY—GLACIATED PEBBLES.

Watt) being Supra Cretaceous, and *f.* R. L. Jack and R. Etheridge, junior, Upper Cretaceous. The solution of this question as to the supposed identity of the friable sandstone of Yellow Cliff with that unconformably capped by Desert Sandstone at Crown Point is of considerable importance as bearing on the probable geological age of the glaciation. No glaciated pebbles were observed by Professor Spencer or Mr. Byrne in the friable sandstone either at Yellow Cliff or Crown Point, though some of its lower beds contain a number of well-rolled quartz pebbles an inch or so in diameter, nor do they think that the glacial pebbles were derived from a disintegration of the friable sandstones. If, therefore, the friable sandstone which at Yellow Cliff immediately underlies the 2 feet to 3 feet bed (out of which the glacial pebbles have weathered) is identical with the steeply-dipping sandstone unconformably capped by desert sandstone at Crown Point, then the next formation below the glacial stratum at Yellow Cliff is Pre-Supra-Cretaceous (Tate and Watt), or Pre-Upper-Cretaceous (Jack and Etheridge), and judged by the degree of induration of the beds is not likely to be as old as Carboniferous, though it may possibly date back to the Permo-Carboniferous. The date of glaciation of the pebbles, according to this view, may be carried even as far back as the Permo-Carboniferous. If, however, the view be adopted, that the Desert Sandstone and the friable kaolin sandstone be conformable to one another, it is possible, though of course it by no means follows, that the age of the latter is Cretaceous. The fact, however, must be mentioned that in some parts of Australia, especially in the western district of New South Wales, as, for example, in the Gulgong and Home Rule District, near Mudgee, the Permo-Carboniferous strata are not only conformable with the Pliocene gold gravels, but also very like lithologically, so that the gold-miners have some difficulty at times in ascertaining in which of the two formations their gold-workings are situated. In other parts, however, of New South Wales, as in the Murrurundi district, there is a marked unconformity between the Tertiary and Permo-Carboniferous rocks.

Possibly analogous conditions may obtain in Central Australia, at Yellow Cliff and at Crown Point respectively, and the friable kaolin sandstone at one point may be discordant, and at another point concordant, with the Desert Sandstone.

In South Australia, also, the strata which contain the glaciated boulders, fringing the coast, southerly and south east from Adelaide, at Hallet's Cove, Inman Valley, Port Victor, and Cape Jervis, are in places only slightly indurated, and there is no marked unconformability between them and the overlying marine Miocene beds, and yet there are reasonable grounds for believing

that these glacial beds may be of Permo-Carboniferous age. Stratigraphical and lithological evidence, therefore, is not opposed to the theory that the friable kaolin sandstone may date back to Permo-Carboniferous time.

The age, however, of the kaolin sandstone may not be by any means synchronous with that of the overlying glacial deposit. Professor Spencer and Mr. Byrne are of opinion that the glaciated pebbles had not weathered out of the kaolin sandstone, and they were unable to find any glaciated pebbles *in situ* in the kaolin sandstone.

There may not, however, be any considerable difference in the age of the two deposits, and, in that case, they may both be referable to some late portion of the Palæozoic or some portion of the Mesozoic era.*

IV. Geographical Position.

Yellow Cliff is on the right side of the Valley of the Finke, or Larapinta, as the aborigines call it. It is situated in longitude 134° 5′ E., and latitude 26° S. With the exception, therefore, of the very doubtful glacial localities in Brazil, it is nearer the Equator than any other locality in the Southern Hemisphere where undoubted traces of Pre-Tertiary glaciation have hitherto been observed. In Southern Africa, the northernmost point to which evidences of Pre-Tertiary glaciation have been traced, is, as far as we are aware, the junction of the Vaal and Orange Rivers, and Weltevreden's Farm, near the same locality. At the latter spot, Mr. E. J. Dunn, formerly Government Geologist of Cape Colony, discovered glacial conglomerates, underlying sandstones containing *Gangamopteris*, and therefore referable to the Dwyka Conglomerates, and at the former locality, in 1885, he found a striated pavement. This is in latitude 29° S., and longitude about 23° 40′ E.

The age of this glaciation is Permo-Carboniferous.

Presumptive evidence of ice action far north in Australia, in Pre-Tertiary time, has previously been adduced, from the Bowen River Coal field, of Queensland, in latitude 23° S., longitude about 149° E.†

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* Speaking for himself, the secretary is inclined to think that the association of glaciated pebbles with the "tumultuously-bedded" kaolin sandstones is, in itself, evidence in favour of the Permo-Carboniferous age of the glaciation. Nevertheless, the time which has elapsed since Middle and Late Mesozoic, and even early Tertiary time, is so vast as to render it impossible probably now to restore the past physical features of Central Australia as they were in Jurassic, Cretaceous, or Eocene time. The possibility of the existence of inland ranges in Australia, at any of the above-mentioned periods, sufficiently high to form a gathering ground for glaciers, must not be excluded. He considers, however, that on the whole, evidence at present, slender as it is, is in favour of a Permo-Carboniferous age for these traces of glaciation in Central Australia.

† Report on the Bowen River Coal-field, by Robert L. Jack, p. 7, paragraph 39. By authority: Brisbane, 1879. Also Pres. Address to Geology Section, by T. W. Edgeworth David. Austr. Assoc. Advt. Sci. Brisbane, 1895. Vol. VI, pp. 63–64.

This evidence is in the form of erratics, up to 2 cubic feet in capacity, sporadically distributed, or occurring in groups, in the marine Permo-Carboniferous strata of the above coal-field. As however, none of the blocks hitherto found, exhibit glacial striæ, their glacial origin cannot, as yet, be said to have been demonstrated. Mr. Jack has suggested as a possible alternative explanation of the phenomena, that the blocks may have been entangled in roots of floating trees, and have been subsequently dropped from them. On the whole, however, the theory that they are ice-borne, appears to us to afford a far more satisfactory explanation.

Mr. Jack states that in his middle, or marine, subdivision of the Bowen series, the remains of trees are neither numerous nor large (and this is the horizon to which the erratics belong), while in the Upper Bowen Series (freshwater), which may be correlated with the Newcastle Series of New South Wales, silicified tree trunks of very large dimensions (up to 3 feet in diameter, and over 40 feet long) are astonishingly numerous, and lie horizontally embedded in the sandstone, which is suggestive of their drift origin. The horizon of the drift timber, therefore, does not coincide with the horizon of the erratics, another fact in favour of the latter being ice-borne.

In the Northern Hemisphere traces of glacial action have been met with even nearer the Equator than Crown Point or the Bowen River Coal-field. Near the village of Irai, in Southern India, striated and grooved rock pavements have been described by Fedden, in latitude 19° 53′ N., at an elevation of 900 feet above the sea. The Talchir boulder beds, in which erratics up to 30 tons in weight are embedded, extend to latitude 17° 20′ N.

V. Summary.

The discovery by Professor Spencer and Mr. P. M. Byrne, of undoubted glaciated pebbles at Yellow Cliff, may therefore throw important light on the extent Equatorwards of the carry of glaciated rocks, possibly in Permo-Carboniferous time, unless the glaciated blocks are the result of some local glaciation in Central Australia, at some later period. It presents another inviting field of research among the many opened up by the Horn Scientific Expedition.

More observations are now urgently needed to show the stratigraphical relationships of the glacial pebbles, particularly to the Desert Sandstone. The Glacial Committee desire to express their thanks to Professor Spencer and Mr. P. M. Byrne, for kindly placing their interesting collection and notes at the disposal of the Glacial Committee.

No. 5.—ON THE EVIDENCE OF GLACIAL ACTION IN THE PORT VICTOR AND INMAN VALLEY DISTRICTS, SOUTH AUSTRALIA.

Fourth Report of the Preceding Committee.

EVIDENCES OF GLACIATION IN THE INMAN VALLEY, YANKALILLA, AND CAPE JERVIS DISTRICTS.

Physical Features.

THE localities referred to in the present notes are comprised within the peninsula which forms the southern limits of the Mount Lofty Ranges. The area is roughly triangular in outline, with Port Victor and Normanville at the base and Cape Jervis at the apex, and is bounded on the sea line by Encounter Bay, Backstairs Passage, and the south-eastern portions of the Gulf St. Vincent.

Between Port Victor and Normanville there is a stretch of relatively low land broken up into minor hills and valleys, bounded on the north and south by ranges of greater magnitude. This main valley is divided transversely by the Bald Hills, which cross the valley at two-thirds distance between Port Victor and Normanville, and forms a water-parting between the seas on either side.

The Inman River takes its rise on the Bald Hills Watershed, about 15 miles west of Port Victor, and empties its waters into Encounter Bay. With its tributary, the Back Valley Creek, it drains an area of about 50 square miles. The flats bordering the river are of small extent, and the valley is occupied by undulating hills that rise 200 feet or more above the level of the stream.

The Bungala River takes its rise on the western flanks of the Bald Hills, and after passing through the township of Yankalilla finds its outlet in the Gulf St. Vincent at Normanville, making a course of 6 miles in length.

The main valley, including the country on both sides of the Bald Hills Watershed, gives a length of 22 miles by road, and a superficial area of a little over 100 square miles. The secondary ranges of the valley, consisting mainly of newer deposits, do not attain a height above sea level much exceeding 600 feet, whilst the average elevation of the enclosing primary rocks is from 800 feet to 1,000 feet. The highlands which define the northern and southern boundaries of the main valley consist of schistose and other metamorphic rocks, and, as measured on the map, are 6 miles apart at the lower end of the valley (where the valley is widest), but they converge on the western side, in the Hundred of Yankalilla, and at two points the valley is narrowed to about 2 miles in diameter.

The physical features of the country lying between Yankalilla and Cape Jervis can be best dealt with when the glacial evidences of this district are described.

Glacial Features.—The Inman Valley.

The Inman Valley holds the first position in the history of the discovery of proofs of former glaciation in Australia, and Mr. Alfred R. C. Selwyn, at that time Government Geologist of Victoria, had the honour of making this discovery. Whilst travelling through the Inman Valley in 1859, engaged on a cursory geological examination of the country under instructions from the South Australian Government, Mr. Selwyn was fortunate in observing a polished rock surface, which, to his practised eye, exhibited clear proofs of glacial action. In his official report he says: "At one point, in the bed of the Inman, I observed a smooth striated and grooved rock surface, presenting every indication of glacial action. The bank of the creek showed a section of clay and coarse gravel, or drift, composed of fragments of all sizes, irregularly imbedded through the clay. The direction of the grooves and scratches is east and west, in parallel lines, or nearly at right angles to the strike of the rocks; and though they follow the course of the stream, I do not think that they could have been produced by the action of water, forcing pebbles and boulders detached from the drift, along the bed of the stream. This is the first and only instance of the kind I have met with in Australia, and it at once attracted my attention, strongly reminding me of the similar markings I had so frequently observed in the mountain valleys of North Wales."* Whilst Selwyn made this striking discovery, he does not seem to have noted the cognate evidences of glaciation in the extensive deposits of drift, glaciated stones, and great erratics which form the chief geological features of the valley.

In May, 1892, Mr. H. Y. L. Brown, Government Geologist, S.A., published an official "Geological Report upon a Shale Deposit in the Hundreds of Encounter Bay and Yankalilla," in which he says: "This formation consists of a jointed shale, varying in colour from a bluish green to black, and interstratified with them there are undulatory beds of sandstone and quartzose sandstone, and occasionally limestone of irregular thickness. The upper portion of this shale, which in some places exhibits a concretionary structure, has become decomposed into clay, and contains water-worn pebbles and boulders of granite, quartzite, sandstone, ironstone, &c. Some of the boulders of granite are of great size, and in character resemble the granite of Victor Harbour. At one or two places on the Inman River there are

*Geological Notes of a Journey in South Australia from Cape Jervis to Mount Serle, No. 20, p. 4.

beds of sandstone grit and boulder sandstone, and these beds rest on the primary rock (quartzite), from which they dip at angles varying from 10° to 15°. They appear to be interstratified with the shale.

"This shale deposit seems to occupy a basin beneath the overlying Tertiary beds, and for that reason its extent cannot be ascertained by a mere surface examination. * * * As a consequence of no fossiliferous remains having been so far met with, no evidences are given of the geological age of this deposit, but as it underlies Miocene Tertiary strata, it may be classed as probably belonging to the older Tertiary or to the Mesozoic rocks."

In relation to the surface geological features of the Inman Valley, Mr. Brown states further, "Large boulders of granite, sandstone, quartzite, quartz, &c., occur along the valley of the Inman River, as well as in other parts of the area, embedded in the clay-beds, and resting on the surface. The presence of these boulders in the position in which they are found can be accounted for only on the supposition that they have been transported from their original position by glacial action."

From the isolated position of this singular clay deposit, differing as it does from all other local rocks, and its uniformly dark colour, Mr. Brown suggested the possibility of its being coal-bearing, and during the three years, 1892–95, the Victor Harbour Coal Company tested it for this object. Three bores were put down in the Back Valley in a lineal direction a mile or two apart. No. 1 Bore reached a depth of 950 feet, and was stopped by jamming of tools before the bed-rock was reached. No. 2 Bore was also choked at a depth of 570 feet, and had to be abandoned. No. 3 Bore recorded a depth of 975 feet, the last 11 feet of which was supposed to be in bed-rock (primary). Particulars of this bore will be given on a later page.

In 1895, in a paper read before the Royal Society, S.A., on "New facts bearing on the Glacial Features of Hallett's Cove,* one of us anticipated that these thick mudstones of the Inman and associated valleys would prove to be of glacial origin, and in age synchronous with the glaciation of Hallett's Cove. There is now little doubt that this is actually the case.

In March last Mr. W. Howchin, F.G.S., of the local Glacial Research Committee, together with Professor David (General Secretary of Research Committee), and Mr. C. C. Brittlebank, of Myrniong, Victoria, visited the Inman Valley and Normanville with the intention of investigating the glacial features of the neighbourhood, and more particularly bent on the re-discovery of the polished glacial pavement referred to by Selwyn in his 1859 report. Starting from Port Victor, the occurrence of large

* Trans. Roy. Soc., S. Aus., Vol. XIX, p. 68.

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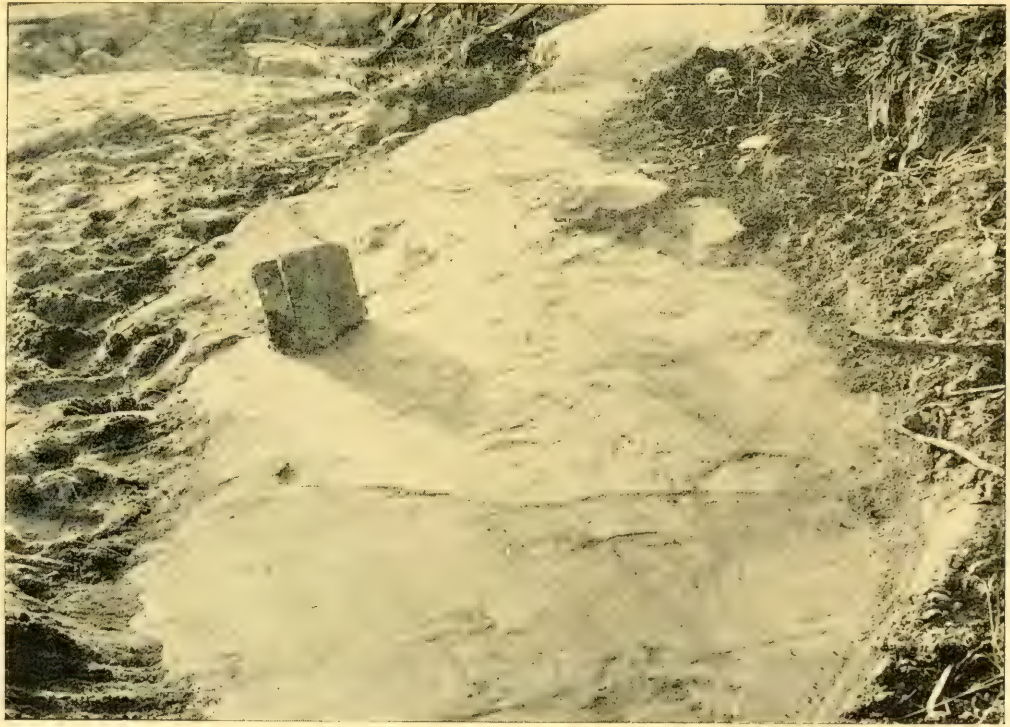

SELWYN'S ROCK. INMAN VALLEY.

erratics became conspicuously evident, both by the roadside and partly exposed in the cultivated ground on either side of the valley. The lower reaches of the Inman River are much silted, its waters flowing over a sandy bed, except where the stream has cut its way by a narrow gorge through a spur of the hills and flows between high perpendicular cliffs.

A little past the seventh milepost from Port Victor, the party made for the river where a low exposure of the older rocks could be seen in outcrop, distant about 248 yards from the public road. This proved to be a very fine glaciated pavement, which we immediately concluded must be "Selwyn's Rock." The bed-rock is a very dense, dark-coloured siliceous quartzite, which at this point occupies the entire bed of the stream. It dips in a direction S. 55° E. at 26°. The principal polished face is on its northern, or left bank, gently sloping to the bed of the river, and in a position which must involve its submergence whenever the river is in flood. The exposed portions of the polished pavement measures over 20 feet in length and 6 feet in breadth. On the water side it has been broken and eroded by the river action, and to landward it has a cover of river silt several feet in height. By clearing away the silty bank, the polished surface was seen to underlie this cover for an unknown distance.

The glaciated pavement is not only highly polished, but deeply grooved and striated. The striæ apparently belong to one system and follow a uniform direction, with a bearing of W. 9½° N., which agrees with the general trend of the main valley. The grooves are broad rather than deep, some of them measuring fully 2 inches in breadth (see pl. 2). A few yards higher up the stream a smaller polished surface is seen on the southern bank, where a washaway has exposed the bed-rock free from cover a few yards away from the stream. The striæ here have the same general direction as on the larger polished face, which is diagonal to the course of the stream, their trend being W. 12° N. Within the limits of the current (as might be expected), the river-bed has been eroded to an extent that has destroyed all evidences of glacial action—the glaciated pavements, on either side of the stream, being above all but abnormal floods. It is also evident that at one time the polished rock has been covered by glacial drift as the inequalities in the floor have been filled with a particularly compact sandstone, corresponding to the local arenaceous drift, only of harder texture. Samples 6 inches thick were taken from some of these depressions, and they are very suggestive of having been formed as a *moraine profonde*. The aneroid reading at this spot indicated a height of 200 feet above sea-level.

If this be the particular glaciated rock discovered by Selwyn, it is evident that the bed of the stream has undergone some changes in the interval. His description of the superficial deposits

of clay and stones resting on the polished rock agree very well with the local drift, whilst the face of rock discovered by the present writers was overlain by a bank of loose river silt. It is quite possible that the bank of glacial drift has been washed away and its place taken by more recent deposits, or otherwise the river silt may have been washed up against the face of drift and thus obscured it. No other examples of polished rock surfaces were observed by us within the limits of the Inman Valley.

Close to this interesting spot, on the northern side of the stream, there is a ridge about 100 feet high which is chiefly of glacial origin. Large and very numerous erratics up to 12 ft. by 13 ft. by at least 3 ft., cover the sides of the hill, the larger number being granite. In places the huge blocks of granite are so closely heaped together that at first sight they were thought to form a natural outcrop. A careful examination, however, proved that this was not the case. Many of the large stones were polished and faceted. These have evidently been weathered out of an extensive bed of glacial drift which originally submerged the hill. Interesting sections of the drift are exposed in some of the lines of erosion cut in the hill sides by the mountain torrents. At this place it is an indurated sandstone thickly studded with erratics of all sizes and has a dip of 10° W.N.W.

At $9\frac{1}{2}$ miles from Port Victor an excellent section of the Drift is seen in the bed of the stream, having a dip of 7° E.S.E., containing numerous boulders of large size. One example of Port Victor granite, which had been washed clear of the matrix, measured 7 ft. by 6 ft., whilst others, almost equally as large, were exposed *in situ* only partially separated from the drift in which they were originally buried.

A quarter of a mile higher up the stream a good section of drift is seen on the north bank, consisting of two very distinct beds. The upper is a friable sand-rock carrying large boulders. This bed has probably, to some extent, been rearranged, as it is a softer stone than is usual with the drift of the locality, but the included stones are mostly heavily striated and give no evidence of river action. Subsequent to glaciation it is not unlikely that the upper drift at this point has slid or been washed down from the high ground on the northern banks. This boulder bed rests on a dark mudstone containing few stones. The undisturbed drift beds at this point gave the same dip as was found a little lower down the stream, viz., 7° E.S.E., and showed a face 30 feet in thickness.

About 150 yards higher up the valley the drift again shows strongly in the bed of the stream as a white indurated sandstone with irregular bands of conglomerate. Dip S. 35° E. at 18°. Here for some distance the bed of the river is almost choked with an immense number of large boulders ; some of these, where

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Erratic Inman Valley.

protected, showed distinct evidences of glaciation. About 200 yards still higher up the valley, where the main road almost touches the stream, near the tenth milepost, a few very large granite boulders occur in the bed of the river, some of which have been drilled and blasted and the pieces utilised to protect the banks from erosion. One of these, a pear-shaped mass, closely resembles the Port Victor granites, and measures 11 ft. by 7 ft. by $4\frac{1}{4}$ ft. The effect of weathering is seen in a partial exfoliation of this large boulder, but in places it still retains the glacial polish and grooving. A photograph of this erratic was taken by Professor David. (Plate 3.)

From the tenth milepost the bed of the river continues to be strewn with large travelled stones, chiefly granite; one measured 8 ft. 6 in. by 5 ft. by 4 ft. 6 in. Another protruding from the glacial Drift on the north bank measured 10 ft. by 7 ft. by 6 ft. Another conspicuous example was of gneiss, giving a beautiful illustration of augen structure, whilst the largest transported stone seen in the bed of the river was observed a little west of the Inman Valley Bridge, near the post-office, and measured 12 feet by 8 feet.

Nearer the source of the Inman the larger erratics are less common, but at intervals the river flows over a bluish-black glacial clay, or argillaceous sandstone, which is very soft, and, apparently, destitute of stones, except some angular fragments of decomposed shale, similar in colour and composition to the bed in which they are included.

The Bald Hills, situated 15 miles from Port Victor, and 7 miles from Normanville, forms the watershed, as already stated, between either sea, and divides the valley into an eastern and western section. This transverse ridge is covered with a peculiar soil, which is very black and deep, such as might be looked for on low marshy ground, but very unusual on the crest of a range. This peculiarity attracted the attention of Selwyn, who says:—"I was unable to ascertain what rock it is that makes the rich black soil of the Bald Hills, but I imagine it to be due to the decomposition of the crystalline limestones, with the addition of some hornblendic and micaceous rocks."* As there are no local limestones, and the bed-rock is a siliceous quartzite, it seems impossible that the dark soil is the product of the decomposition of the local rocks. It is more likely to have been derived from the dark-coloured glacial clay, which can be traced to the eastern flanks of the Bald Hills, and, doubtless, at one time covered their summits. This is made the more plausible as there are abundant evidences that the ice passed over the top of the Bald Hills at a height of 640 feet above sea-level. A good section of drift with

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* Op. cit. p. 4.

stones is seen in a cutting by the road-side, just over the western crest of the hill, whilst on the southern side of the road the steep water-worn gullies are full of erratics and good sections of glacial drift, *in situ* with many ice-worn stones.

Here also, near the sixth milepost from Normanville, in the upper waters of the Bungala River, two small faces of polished pavement were recognised in a narrow mountain torrent. The aneroid reading was 395 feet above sea-level, and the polished rock is a hard and dark-coloured siliceous quartzite, identical in character with the more important face in the Inman Valley. The two polished slabs were in the same watercourse at slightly different levels (about 20 feet), and on one of them is a conspicuous vein of white quartz that has been planed down to the same level as the quartzite matrix. The strike of the striæ is E. 24° S., and there is a continuous bed of glacial drift covering the rock between the polished faces.

The gathering darkness prevented a close examination of the country between the Bald Hills and Normanville, and the bed of the Bungala is much silted so as to obscure all but the most recent deposits. On the following morning, however, a flying visit was paid to the hills bordering the sea on the north side of Normanville, when striated stones were picked up on the heights with rearranged sandy material 200 feet above sea-level.

THE BACK VALLEY.

In a second visit to this neighbourhood, by one of us, observations have been made over a much wider area than that already described. The Back Valley country runs parallel with the Inman Valley, from which it is separated by a high ridge that is continuous for about 6 miles. This dividing range was crossed by following a district road that joins the main road about 7½ miles from Yankalilla, passing the house of Mr. Thomas Mayfield. At an elevation of about 300 feet above the Inman a large rounded boulder of granite can be seen in a paddock on left-hand near to the fence. It measures 7½ feet by 7½ feet. Granitic boulders continue to be seen up to the crest of the hill, estimated to be 500 feet above the level of the Inman, and perhaps 100 feet higher than the road which passes over the Bald Hills. Near the top of the hill there is a granite boulder 3 feet in diameter.

After passing the crest of the hill the ground falls away, and at about 100 feet less elevation the road passes along the summit of one of the secondary ranges of the Black Valley with a trend S.S.E. and N.N.W. At the head of the road, near Mr. Marshall's house, a road cutting extends for about 100 yards, exhibiting soft yellow sandstones, unstratified, but contorted. Strings of dark-coloured argillaceous material run most irregularly through the stone, sometimes forming loops. No stones were actually

seen embedded in the sandstone, but striated pebbles were picked up both on the natural surface of the ground as well as in the loose sand of the road cutting, having, to all appearances, been weathered out of the sandstone.

With the road still descending towards the valley, at a short distance from the cutting just referred to, a second occurs of precisely similar features associated with glaciated stones, and at a further distance of a quarter of a mile a stony patch is exposed on the northern slopes of the hill in the adjoining paddock, many of the stones showing glacial features.

We descended to the Back Valley Creek to find the bores put down in the neighbourhood by the Victor Harbour Coal Company, but failed to discover them. The country is cut up into high ridges and numerous narrow gullies, and densely covered with scrub. The bed of the creek is shallow and much silted, and only in two places was the yellow sandstone (? glacial drift) seen in outcrop, and these were in conspicuous patches in the bed of the creek.

It is to be regretted that no experienced person seems to have examined the material taken from the bores referred to, and the only information available as to the strata passed through is contained in the log-book kept by the man in charge. The three bores seem to have closely resembled each other in the nature of the beds penetrated, and we subjoin particulars of No. 3 bore, which was the deepest of the three :—

Nature of Strata.	Thickness in Feet.		Depth from Surface,	
	ft.	in.	ft.	in.
Surface clay	15	0	15	0
Shale	55	0	70	0
Sandstone rock	0	8	70	8
Shale, with layers of sand	39	4	110	0
Sandstone rock	0	6	110	6
Shale and sand	19	6	130	0
Sandstone rock	0	9	130	9
Shale and sand	19	3	150	0
Sandstone rock	0	6	150	6
Sand and shale	61	6	212	0
Sandstone rock	2	0	214	0
Sand and shale—nearly all sand	21	0	235	0
Solid shale	20	0	255	0
Sand	45	0	300	0
Shale and sand	6	0	306	0
Sandstone rock	0	9	306	9
Sand and shale—nearly all sand	193	3	500	0
Solid sand—almost a sandstone	196	0	696	0
Sand and boulders, with occasional small bands of conglomerate	268	0	964	0
Blue hard rock (primary)	11	0	975	0

Bore stopped.

BALD HILLS AND YANKALILLA.

Followed the crest of the Bald Hills on north side of the public road and observed granitic and other erratics scattered over the fields of Mr. J. R. Kelly, M.P., at Cornhill, and picked up strongly-glaciated quartz pebble near the source of the Inman, a little above the Bald Hills post-office.

On the western slopes of the Bald Hills watershed, erratics are common, especially in the tributaries of the Bungala River. Near the fourth milepost from Yankalilla, 6 miles from Normanville, there is a conspicuous face of drift on Mr. Capper's ground, seen from the road on the south bank of the creek near the house. The section is about 200 yards long by 15 feet high, and consists of soft, yellowish sandstone, studded with numerous erratics.

By far the largest and most interesting exposure of the glacial beds of the neighbourhood is seen in Wood's Creek, about a mile from the centre of the township of Yankalilla, and a few hundred yards above the junction which the creek makes with the Bungala River. For many years this stone has been worked as "the Government quarry" for making and metalling the roads, the quarry face extending 150 yards laterally, and has exposed a thickness of stone of over 50 feet from the bed of the creek to the top of the quarry. The stone is a white, yellow, and grey sandstone, decomposing into loose sand near the surface, but, at depth, passes into a compact grit. The bedding is a little uncertain. On one side of the quarry, what appeared to be bedding planes with a rolling curvature dipped towards the creek at an angle of 20° N.N.W. The stone is conspicuously jointed both vertically and obliquely, and where compact can only be won by blasting. The bed is crowded with erratics of great variety, but on account of the intimate union between the included stones and the matrix, sometimes they can only be recognised by a close examination of the face. Granite (of Port Victor type) is the most common. One example of this kind was exposed on the quarry face that gave the measurement 18 in. x 10 in. Others exhibited opalescent quartz as a constituent exactly corresponding to a variety found at Port Elliot. Amongst the erratics were also noticed mica schist, different coloured quartzites, quartz pebbles, crystals of orthoclase, &c. The granite and schists have undergone considerable decomposition, but most of the quartzites and quartz pebbles retain striking evidences of glaciation. The finer material consists of quartz sand, mostly rounded, strangely intermixed as to size, whilst the cementing agent is apparently a silicate resembling pipeclay, possibly the product of the grinding down of the orthoclase of the granitic rocks. The junction between the glacial beds and the older rocks is clearly exposed in the creek, where the former are seen to rest unconformably on dark-coloured

quartzite, thickly penetrated with a network of syenitic and other igneous veins. The bed-rock has a dip of 45° N.E., but is much disturbed through igneous intrusions. So far as could be seen, the bed-rock did not show glaciation at the line of contact between it and the glacial drift. The indurated and jointed character of the newer rocks is strongly suggestive of Palæozoic age.

A little higher up stream the glacial beds run out, and are replaced by the metamorphic rocks, but other outcrops were found at several spots. Half a mile above the Government quarry two angular pieces of yellow sandstone are seen jutting from the banks on the east side, and a little higher up two patches *in situ* are seen on the same side, one of them showing an outcrop of 9 yards by 2 feet thick exposed from beneath the alluvial banks. Boulders of the same material were found among the river gravel, at intervals, to the bridge, which was as far as the stream was followed, indicating further outcrops of the same rock in the upper reaches of the creek.

FROM YANKALILLA TO CAPE JERVIS.

The journey from Yankalilla to Cape Jervis and back was done in the day, and as it involved a distance of 46 miles no divergence could be made from the road. The opportunities therefore for examining the geological features of the country were extremely restricted, and were confined to what caught the eye of the observer from the conveyance. It is only fair to make this statement, as otherwise, the evidence of glacial phenomena over this country would no doubt have been recognised to a much wider extent. Glacial deposits were seen in two cuttings on the public road as follows:—

1. About 9 miles from Yankalilla and 1 mile south of Mr. E. C. Kelly's water-trough, the road passes through a clay cutting about 8 feet high. On the eastern bank, near the top, an ice-borne stone was recognised. It is a subangular block of red-coloured quartzite, rough on some faces and highly polished and striated on others. Measures 16 in. x 12 in., with a circumference of 32 in. x 31 in., and in weight is as much as a man can lift from the ground.* In the same cutting, close to the preceding, there is a much larger fragment of angular grey quartzite measuring $2\frac{1}{4}$ ft. x $1\frac{1}{2}$ ft. No glaciation could be detected on the surfaces of the stone exposed above the clay. Estimated height above sea-level, 300 ft.

2. Another example of boulder clay was recognised on the south side of Fowler's Hill, just past the thirteenth milepost from Yankalilla (59 miles from Adelaide). It occurs as a pocket in a valley of erosion in calcareous shales near the top of the hill. It

* This erratic has been brought to Adelaide, and is now in the possession of Walter Howchin.

is seen on the eastern side of the road only ; is 33 yards long, 12 ft. high, with base not exposed. The clay carries erratics showing glaciation, which, though numerous are small, the largest one noticed was a greenish quartzite, 12 in. x 6 in. striated. Estimated height above sea-level, 500 ft.

CAPE JERVIS.

Selwyn, in his report already quoted, mentioned the occurrence of granitic boulders in the fields at the Cape, which he thought must have come from Kangaroo Island, but he failed to recognise their significance in conjunction with the Till which has an important local development. His observations, however, made us the more anxious to see the locality, and we were rewarded in finding the most extensive deposits of a genuine Till yet discovered in South Australia.

The bed-rock consists of dark-coloured arenaceous shales and schistose rocks, which, in outcrop, are much decomposed and crumbling. They have a strike north and south, and an easterly dip averaging about 45°. Their serrated edges occupy the beach and in places rise a few feet above high-water mark.

Hills of morainic material, over 100 feet high, rise crescent-shape behind the light-house and follow the northern trend of the coast in a steep cliff face.

Large erratics occur in the light-house yard and can also be seen singly or in groups scattered over the sides of the hills as viewed from the light-house buildings. In one granitic group I counted thirty close together, partially weathered from the Till in which they were imbedded. The largest had an exposed face of 5½ feet. Near to these was a large block of grey quartzite standing 18 inches out of the ground, and strongly glaciated. A short distance away from this group was a large rounded boulder of granite measuring 3 ft. 3 in., much weathered, and close by it a large bluish-coloured quartzite with a mass of 7 ft. 6 in. x 3 ft. 9 in. exposed above the Till.

On the beach, north of the light-house, and near the commencement of the high cliffs of Till, three large erratics occur close together. (1) Granite, 4 ft. 6 in. x 2 ft. x 2 ft. 4 in., having a flat fractured face extending over entire width of stone; (2) granite, 3 ft. 3 in. x 2 ft. 6 in. also shows large fractured face; (3) quartzite, 4 ft. 3 in. x 2 ft. 6 in. x 2 ft. 10 in.

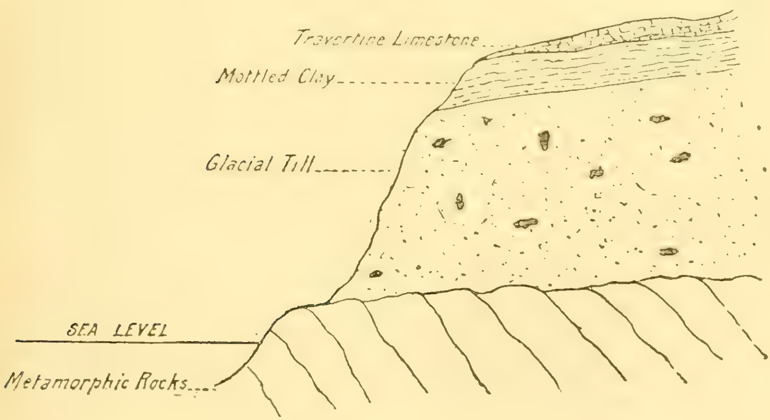
The Till is unstratified and very characteristic. It varies in colour from grey to almost black, and is full of boulders of all sizes. About half a mile along the north beach from the light-house a large granite boulder is seen fixed in Till on face of cliff, 4 ft. x 5 ft. It is of coarse texture, and includes large rounded crystals of orthoclase similar to the Port Victor granite. Not much time could be devoted to the smaller erratics, but the occur-

rence of rounded quartz-pebbles, especially on the hill sides, where the rain had washed the soil away, is a peculiar feature. These quartz pebbles, in common with most of the stones included in the Till, show distinct evidences of glaciation.

The boulder clay rests unconformably on the edges of the metamorphic rocks. No glaciated pavement could be seen, and to all appearance the line of junction between the two formations was rough and uneven. At the same time it must be said that the examination was limited, and the bed-rock is so soft and friable that it is not adapted for either taking or preserving a glacial face.

The thickness of the Till bed at Cape Jervis is estimated at something over 100 feet, and is capped by variegated (? miocene) clays and travertine limestone. How far the boulder clay extends along the coast in either direction we were unable to ascertain in our hurried visit. The outcrop was followed along the northern cliffs for about a mile from the light-house without coming to its limits. At the furthest point reached the Till is a very black clay, studded with stones in an irregular manner. A good section is seen at this furthest point reached, in a deep washaway about 3 feet to 6 feet wide, and 15 feet deep.

SECTION AT CAPE JERVIS.



EXTENT OF THE ICE-FIELD.

The country on the north side of Yankalilla has not been examined for glacial features, but from what could be gathered from observations made in a journey, by coach, over the ground,

it is highly probable that glacial deposits extend in a northerly direction between Yankalilla and Myponga for a distance of nearly 10 miles, and were bounded in that direction by the lofty Sellicks Hill Range. The glaciation of the Cape Jervis Peninsula has now been demonstrated on two sides of the geographical triangle marked by Port Victor, Normanville, and Cape Jervis, and we may safely conclude that practically the whole of the country included within the area indicated has been visited by ice, and can be estimated at about 300 square miles. This estimate does not include the important outlier of glacial beds at Hallett's Cove, 45 miles further north than Normanville.

GENERAL CONSIDERATIONS.

In our present limited knowledge of this great extinct ice-field it would be rash to express a definite opinion either as to the geological age of these deposits or the conditions under which the glacial phenomena occurred. We may affirm, however,—

1. *That the glaciation was on a scale of considerable magnitude*, as may be inferred from the following facts :—

(*a*) *The thickness of the Glacial Drift.*—In the Back Valley borings have disclosed a deposit which there can be little doubt is of glacial origin, nearly 1,000 feet in thickness, To this must be added the wash these beds have undergone at the surface, which amounts apparently to over 600 feet, giving a total of more than 1,500 feet as the original thickness of the glacial drift in the valleys referred to. Even at so great a distance from the centre of dispersion as Hallett's Cove, there is a known thickness of over 100 feet above sea-level, with an unknown thickness below low-water mark, in the old valley now occupied by the Gulf St. Vincent.

(*b*) *The transporting power of the ice must have been great.* What may be regarded as the great glacial highways,—the Inman and Bungala Valleys, Cape Jervis, and the depression of Gulf St. Vincent,—are in places crowded with very large erratics. There is a block moved by ice action at Hallett's Cove, equal to the size of a small cottage, and on the beach below hundreds of travelled stones that would weigh over a ton each.

2. *As to the Geological Age*, the capping of mottled clays resting on the drift at Cape Jervis (as at Hallett's Cove), is suggestive of a Pre-Miocene age for the refrigeration of the Australian climate. The section at Cape Jervis, has not, however, been closely examined, and the evidence from that locality must be taken

subject to revision. The highly indurated and jointed features of the deposits at Government quarry, Yankalilla, differ in these respects from any known Tertiary rocks in South Australia, and are suggestive of a higher geological age.

3. *With regard to the stratigraphical characteristics*,* much remains to be done. The glacial drift, as developed in the Inman and associated valleys, does not agree very closely with the typical boulder clay of the Northern Hemisphere. It is more characteristically arenaceous than argillaceous, varying from loose sand, to sand-rock, sandstones, grits, and conglomerates. Even the so-called "shales" in the Government Geologists Report, and the borings of the Victor Harbour Coal Company, would seem to be an arenaceous rock of a dark mud-stone character. The nearest approach to a true clay deposit is got at Hallet's Cove, and the best example of Till—unstratified clay with glaciated stones irregularly distributed through the mass—is found at Cape Jervis.

THE GLACIAL AGENT.

4. It is not attempted, at the present stage of observations, to say positively whether the glacial phenomena were effected by glacier, iceberg, or shore ice. The powerful ground glaciation in the Inman, on the Bald Hills, and over a great extent of surface at Hallett's Cove, the *roches moutounées* (at the latter place particularly), as well as the persistency and regularity of the striæ, would seem to demand land ice of considerable extent for their production. If icebergs are assumed to be the cause of the glacial phenomena, they must have been of local origin, as the morainic material has evidently been gathered from our own shores, whilst local icebergs would also require local glaciers to give birth to them. Shore ice would certainly explain some of the features, as, for example, the number of water-worn pebbles which are found in the drift, both at the Cape and Inland. These pebbles have certainly first been subjected to river or coastal attrition, and have been subsequently faceted by ice movements. The glacial beds in the Inman Valley have at present an elevation of over 600 feet above sea-level. If, therefore, we admit the agency of shore ice as the means of distribution, we must assume that there has been since the days of glaciation an elevation of the land in the neighbourhood at least equal to that mentioned above. The facts are perhaps best explained by reference to a combination of agencies rather than to a single form of ice action.

No. 6.—LIST OF VERNACULAR NAMES FOR AUSTRALIAN BIRDS.

Report of the committee, consisting of the Rev. H. Atkinson, Dr. R. H. Perks, Colonel Legge, F.L.S., M.B.O.U., Messrs. Barnard, A. Zietz, M. S. Clark, A. Morton, F.L.S., A. J. Campbell, F.L.S., C. W. De Vis, M.A., F. Cheeseman, F.L.S., A. J. North, F.L.S., and H. Thorpe, Professors W. Baldwin Spencer, M.A., F. W. Hutton, F.R.S., T. J. Parker, F.R.S., Sir James Hector, F.R.S., and Dr. E. C. Stirling, F.R.S., (Secretary).

[Drawn up by Messrs. A. J. CAMPBELL, C. W. DE VIS, Colonel LEGGE, and DR. STIRLING.]

THE need, for numerous reasons, of an acceptable "Vernacular List" of Australian Birds' names was first mentioned at the Hobart meeting of the Science Association, 1892.

The following year, at the Adelaide meeting, a committee was appointed to deal with the matter—*Vide* vol. V of the "Proceedings," p. XXII.

The committee was found to be somewhat large, and, as the list was to be purely an Australian one, the New Zealand members were not consulted.

Colonel Legge (Tasmania) and Mr. A. J. Campbell (Victoria) were deputed by the secretary of the committee to draw out a preliminary list. After considerable research by these two gentlemen the list was compiled, principally on the lines indicated in Colonel Legge's memorandum, published in vol. VI (Brisbane, 1895), p. 445, and was forwarded to Adelaide, August, 1894.

The list was then considered and finished, 30th November, 1894, by the south and western committee at Adelaide which approved generally of the principles laid down in the preliminary list and made the following suggestions:—That the final list be issued in tabular form with reference to Gould's Nos., in addition to the scientific and vernacular names; that, where scientific names have been altered, the older or more familiarly-known terms be retained in brackets; and that if any species appearing on existing lists be omitted, a reason or reference should be stated for such omission.

On the 11th December, 1894, or one month prior to the opening of the next (Brisbane) Congress, the list was forwarded to Mr. A. J. North at the Australian Museum as representative of the New South Wales committee. Mr. North delegated his power to

NOTE.—This list was adopted by The Australasian Association for the Advancement of Science, at the Sydney Congress, 1898, the basis of the classification being taken from the "Catalogue of Birds," of the British Museum, in the order the volumes appeared, excepting No. XXVI, which is still unpublished.

Colonel Legge and Mr. Campbell (*vide* letter from the Curator, Mr. R. Etheridge, junr.), and passed the list on to Mr. C. W. De Vis, who represented Queensland. Mr. George Masters, another member of the New South Wales committee, begged to decline acting on account of his many engagements.

As little time remained for the consideration of the list at the Brisbane Congress, Mr. De Vis (who stated that the Queensland branch of the committee was prepared to adopt the principles of popular nomenclature advocated in the preliminary list) suggested that it should be brought up at the Sydney Congress (1898) for final adoption, and that the main features of modern classification should be introduced in whatever form the list might appear.

The "Vernacular List" is now presented for adoption, the classification and scientific nomenclature being in accordance with the "Catalogue of Birds" of the British Museum, kindly extracted for the committee by Mr. Ed. Degen.

E. C. Stirling,
Secretary, Vernacular Names Committee.

ORDER—ACCIPITRES: BIRDS OF PREY.

Sub-order—Falcones: "Falcons."

FAMILY—FALCONIDÆ: "HAWKS."

Sub-family—Accipitrinæ: "Long-legged Hawks."

1. Circus assimilis (jardinii). "Spotted Harrier."
2. Circus gouldi (assimilis). "Harrier" (Swamp-hawk).
3. Astur (Leucospiza) cinereus. "Grey Goshawk."
4. Astur (Leucospiza) novæ-hollandiæ. "White Goshawk."
4A. Astur leucosomus. "Lesser White Goshawk."
5. Astur approximans. "Goshawk."
6. Astur cruentus. "Lesser Goshawk."
7. Accipiter cirrhocephalus. "Sparrow-hawk."

Sub-family—Buteoninæ: "Buzzards."

8. Urospizias radiatus. "Red Goshawk."

Sub-family—Aquilinæ: "Eagles."

9. Uroaetus (Aquila) audax. "Wedge-tailed Eagle" (Eagle-hawk).
10. Nisætus (Aquila) morphnoides. "Little Eagle."
11. Haliaetus leucogaster. "White-bellied Sea-Eagle."
12. Haliastur girrenera. "White-headed Sea-Eagle."

13. Haliastur sphenurus. "Whistling Eagle."
14. Milvus affinis. "Kite."
15. Lophoictinia (Milvus) isura. "Square-tailed Kite."
16. Gypoictinia melanosterna. "Black-breasted Buzzard."
17. Elanus axillaris. "Black-shouldered Kite."
18. Elanus scriptus. "Letter-winged Kite."

SUB-FAMILY—FALCONINÆ: "FALCONS."

19. Baza subcristata. "Crested Hawk."
20. Falco melanogenys. "Black-cheeked Falcon."
21. Falco hypoleucus. "Grey Falcon."
22. Falco subniger. "Black Falcon."
23. Falco lunulatus. "Little Falcon."
24. Hieracidea berigora (occidentalis). "Striped Brown Hawk."
25. Hieracidea orientalis (berigora). "Brown Hawk."
26. Cerchneis (Tinnunculus) cenchroides. "Kestrel."

Sub-order—Pandiones: "Ospreys."

27. Pandion leucocephalus. "Osprey" (Fish-hawk.")

Sub-order—Striges: "Owls."

FAMILY—BUBONIDÆ: "OWLS" PROPER.

SUB-FAMILY—BUBONINÆ.

28. Ninox boobook (1). "Boobook Owl."
29. Ninox ocellata. "Marbled Owl."
30. Ninox maculata. "Spotted Owl."
31. Ninox connivens. "Winking Owl."
32. Ninox strenua (2). "Powerful Owl."
32A. Ninox humeralis,
33. Ninox peninsularis. "Cape York Owl."
34. Ninox occidentalis. "Western Winking Owl."
35. Ninox lurida. "Lurid Owl."

FAMILY—STRIGIDÆ: "BARN OWLS."

36. Strix novæ hollandiæ. "Chestnut-faced Owl."
37. Strix delicatula. "Lesser Masked Owl."
38. Strix castanops. "Masked Owl."
39. Strix tenebricosa. "Sooty Owl."
40. Strix candida. "Grass Owl."

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(1) Includes *N. marmoratus* (Marbled Owl). (2) Includes *N. rufus* (Rufous Owl).

ORDER—PASSERIFORMES: "PERCHING BIRDS."

Sub-order—Passeres.

FAMILY—CORVIDÆ: "CROWS."

SUB-FAMILY: CORVNINÆ: "CROWS" PROPER.

41. Corvus coronoides. "Crow."
42. Corone australis. "Raven."
43. Strepera graculina. "Pied Crow-Shrike."
44. Strepera arguta. "Hill Crow-Shrike."
45. Strepera intermedia. "Lesser Crow-Shrike."
46. Strepera cuneicaudata. "Grey Crow-Shrike."
47. Strepera plumbea. "Leaden Crow-Shrike."
48. Strepera melanoptera. "Black-winged Crow-Shrike."
49. Strepera fuliginosa. "Black Crow-Shrike."
50. Struthidea cinerea. "Grey Jumper."

SUB-FAMILY—FREGILINÆ: "CHOUGHS."

51. Corcorax melanorhamphus. "White-winged Chough."

FAMILY—PARADISEIDÆ: "BIRDS OF PARADISE."

SUB-FAMILY—EPIMACHINÆ.

52. Ptilorhis paradisea. "Rifle-bird."
53. Ptilorhis victoriæ. "Victoria Rifle-bird."
54. Ptilorhis alberti. "Albert Rifle-bird."

SUB-FAMILY—PARADISEINÆ.

55. Phonygama (Manucodia) gouldi. "Manucode."

FAMILY—ORIOLIDÆ: "ORIOLES."

56. Oriolus affinis. "Northern Oriole."
57. Oriolus flavicinctus. "Yellow Oriole."
58. Oriolus viridis. "Oriole."
59. Sphecotheres maxillaris. "Fig-bird."
60. Sphecotheres flaviventris. "Yellow-bellied Fig-bird."

FAMILY—DICRURIDÆ: "DRONGOS."

61. Chibia bracteata. "Drongo."

FAMILY—PRINOPIDÆ: "WOOD-SHRIKES."

SUB-FAMILY—PRINOPINÆ.

62. Grallina picata. "Magpie Lark."
63. Collyriocincla harmonica. "Grey Shrike-Thrush."

64. Collyriocincla rectirostris. "Whistling Shrike-Thrush."
65. Collyriocincla brunnea (1). "Brown Shrike-Thrush."
66. Collyriocincla rufiventris. "Buff-bellied Shrike-Thrush."
67. Collyriocincla pallidirostris. "Pale-bellied Shrike-Thrush."
68. Collyriocincla boweri (2). "Bower Shrike-Thrush."
69. Collyriocincla cerviniventris. "Fawn-breasted Shrike-Thrush."
70. Pinarolestes parvulus. "Little Shrike-Thrush."
71. Pinarolestes rufigaster (3). "Rufus-breasted Shrike-Thrush."

FAMILY—CAMPOPHAGIDÆ: "CUCKOO-SHRIKES."

72. Pteropodocys phasianella. "Ground Cuckoo-Shrike."
73. Graucalus melanops. "Black-faced Cuckoo-Shrike."
74. Graucalus parvirostris. "Small-billed Cuckoo-Shrike."
75. Graucalus hypoleucus. "White-bellied Cuckoo-Shrike."
76. Graucalus mentalis. "Little Cuckoo-Shrike."
77. Graucalus lineatus. "Barred Cuckoo-Shrike."
78. Edoliisoma (Campophaga) tenuirostre (jardinii). "Caterpillar-eater."
79. Lalage (Campophaga) tricolor. White-shouldered Caterpillar-eater."
80. Lalage (Campophaga) leucomelæna (4). "Pied Caterpillar-eater."

FAMILY—MUSCICAPIDÆ: "FLY-CATCHERS."

81. Micrœca fascinans. "Brown Fly-catcher."
82. Micrœca assimilis. "Lesser Brown Fly-catcher."
83. Micrœca flavigaster. "Lemon-breasted Fly-catcher."
84. Micrœca pallida. "Pale Fly-catcher."
85. Petrœca leggii (multicolor). Scarlet-breasted Robin."
86. Petrœca phœnicea. "Flame-breasted Robin."
87. Petrœca rhodinogastra. "Pink-breasted Robin."
88. Petrœca rosea. "Rose-breasted Robin."
89. Petrœca goodenovi. "Red-capped Robin."
90. Petrœca ramsayi. "Red-throated Robin."
91. Petrœca bicolor (cucullata). "Hooded Robin."
92. Petrœca picata. "Pied Robin."
93. Petrœca vittata. "Dusky Robin."
94. Smicrornis brevirostris. "Short-billed Tree-Tit."
95. Smicrornis flavescens. "Yellow-tinted Tree-Tit.
96. Gerygone albigularis. "White-throated Fly-eater."
97. Gerygone cinerascens. "Grey Fly-eater'"
98. Pseudogerygone culicivora. "Southern Fly-eater."

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(1) Includes *C. superciliosa*. (2) Includes *C. sibila*. 3) Includes *C. parvissima*.
(4) Includes *Campephaga karu*.

99. Pseudogerygone magnirostris. "Large-billed Fly-eater."
100. Pseudogerygone fusca. "Brown Fly-eater."
101. Pseudogerygone lævigastra. "Buff-breasted Fly-eater."
102. Pseudogerygone chloronata. "Green-backed Fly-eater."
103. Pseudogerygona personata (1). "Black-throated Fly-eater."
104. Pœcilodryas nana. "Little Robin."
105. Pœcilodryas superciliosa. "White-browed Robin."
106. Pœcilodryas capito. "Large-headed Robin."
107. Pœcilodryas cerviniventris. "Buff-sided Robin."
108. Pœcilodryas albifacies. "White-faced Robin."
109. Malurus cyaneus. "Blue Wren."
110. Malurus cyanochlamys. "Silvery Blue Wren."
111. Malurus gouldi. "Long-tailed Blue Wren."
112. Malurus melanotus. "Black-backed Wren."
113. Malurus callainus. "Turquoise Wren."
114. Malurus splendens. "Banded Wren."
115. Malurus leucopterus. "White-winged Wren."
116. Malurus leuconotus. "White-backed Wren."
117. Malurus elegans. "Red-winged Wren."
118. Malurus lamberti. "Variegated Wren."
119. Malurus amabilis (2). "Lovely Wren."
120. Malurus pulcherrimus. "Blue-breasted Wren."
121. Malurus coronatus. "Purple-crowned Wren."
122. Malurus dorsalis (cruentatus). "Red-backed Wren."
123. Mulurus cruentatus-boweri. "Bower Red-backed Wren."
124. Malurus melanocephalus. "Orange-backed Wren."
125. Rhipidura albiscapa. "White-shafted Fan-tail."
126. Rhipidura preissi. "Western Fan-tail."
127. Rhipidura diemenensis. "Dusky Fan-tail."
128. Rhipidura rufifrons. "Rufus Fan-tail."
129. Rhipidura dryas. "Wood Fan-tail."
130. Rhipidura setosa (isura). "Northern Fan-tail."
131. Rhipidura albicauda. "White-tailed Fan-tail."
132. Rhipidura phasiana. "Pheasant Fan-tail."
133. Rhipidura (Sauloprocta) tricolor (motacilloides) (3). "Black and White Fan-tail."
134. Myiagra rebecula (plumbea). "Leaden Fly-catcher."
135. Myiagra concinna. "Blue Fly-catcher."
136. Myiagra nitida. "Satin Fly-catcher."
137. Myiagra latirostris. "Broad-billed Fly-catcher."
138. Machærorhynchus flaviventer. "Yellow-breasted Fly-catcher."
139. Sisura inquieta. "Restless Fly-catcher."
140. Sisura nana. "Little Fly-catcher."
141. Arses kaupi (4). "Pied Fly-catcher."

(1) Includes *G. flavida*. (2) *M. hypoleucos* is the female of this species.
(3) Includes *Sauloprocta picata*—a smaller race. (4) Includes *A. terræ-reginæ*.

142. Arses lorealis. "Frill-necked Fly-catcher."
143. Piezorhynchus nitidus. "Shining Fly-catcher."
144. Piezorhynchus gouldi (trivigata) ([1]). "Spectacled Fly-catcher."
145. Piezorhynchus leucotis. "White-eared Fly-catcher."
146. Monarcha melanopsis (carinata). "Black-faced Fly-catcher."
147. Monarcha canescens. "Pearly Fly-catcher."

FAMILY—TURDIDÆ: "TRUE THRUSHES."

SUB-FAMILY—SYLVIINÆ: "WARBLERS."

148. Acrocephalus longirostris. "Long-billed Reed-Warbler."
149. Acrocephalus australis. "Reed-Warbler."

SUB-FAMILY—TURDINÆ: "THRUSHES."

150. Geocichla (Oreocincla) lunulata. "Ground-Thrush."
151. Geocichla macrorhyncha. "Large-billed Ground-Thrush."
152. Geocichla heinii. "Russet-tailed Ground-Thrush."
153. Geocichla cuneata. "Broadbent Ground-Thrush."

FAMILY—TIMELIIDÆ: "BABBLING THRUSHES."

SUB-FAMILY—PTILONORHYNCHINÆ:* "BOWER-BIRDS."

154. Ptilonorhynchus violaceus. "Satin Bower-bird."
155. Aelurœdus maculosus. "Spotted Cat-bird."
156. Aelurœdus viridis. "Cat-bird."
157. Chlamydodera maculata. "Spotted Bower-bird."
158. Chlamydodera guttata. "Yellow-spotted Bower-bird."
159. Chlamydodera nuchalis. "Great Bower-bird."
160. Chlamydodera orientalis. "Queensland Bower-bird."
161. Chlamydodera cerviniventris. "Fawn-breasted Bower-bird."
162. Scenopæus dentirostris. "Tooth-billed Bower-bird."
163. Sericulus melinus. "Regent-bird."
164. Prionodura newtoniana. "Golden Bower-bird."

SUB-FAMILY—TIMELIINÆ: "BABBLERS," &c.

165. Stipiturus malachurus. "Emu Wren."
166. Sphenura brachyptera. "Bristle-bird."
167. Sphenura longirostris. "Long-tailed Bristle-bird."
168. Sphenura broadbenti. "Rufous Bristle-bird."
169. Amytis textilis. "Grass-Wren."
170. Amytis striata. "Striated Grass-Wren."
171. Amytis macrura. "Large-tailed Grass-Wren."
172. Amytis goyderi. "Goyder Grass-Wren."

([1]) Includes *P. albiventris*.
* This family should probably follow the *Paradiseidæ* (Birds of Paradise).

173. Megalurus gramineus. "Grass-bird."
174. Megalurus galactotes. "Tawny Grass-bird."
175. Origma rubricata. "Rock-Warbler."
176. Cisticola exilis.(1) "Grass-Warbler."
177. Chthonicola sagittata. "Little Field-Lark."
178. Acanthiza nana. "Little Tit."
179. Acanthiza inornata. "Plain-coloured Tit."
180. Acanthiza pusilla. "Brown Tit."
181. Acanthiza diemenensis. "Brown-rumped Tit." (Brown-tail.)
182. Acanthiza apicalis. "Broad-tailed Tit."
183. Acanthiza pyrrhopygia. "Red-rumped Tit."
184. Acanthiza lineata. "Striated Tit."
185. Acanthiza uropygialis. "Chestnut-rumped Tit."
186. Acanthiza chrysorrhoa. "Yellow-rumped Tit."
187. Acanthiza reguloides. "Buff-rumped Tit."
188. Acanthiza squamata. "Scaly-breasted Tit."
189. Sericornis (Pyrrholæmus) brunnea. "Red-throat."
190. Sericornis citreogularis. "Yellow-throated Scrub-Wren."
191. Sericornis frontalis (2). "White-browed Scrub-Wren."
192. Sericornis magnirostris. "Large-billed Scrub-Wren."
193. Sericornis lævigastra. "Buff-breasted Scrub-Wren."
194. Sericornis maculata. "Spotted Scrub-Wren."
195. Sericornis (Acanthornis) magna. "Scrub-Tit."
196. Sericornis osculans. "Spotted-throated Scrub-Wren."
197. Sericornis humilis. "Brown Scrub-Wren."
198. Sericornis minimus. "Little Scrub-Wren."
199. Sericornis guttaralis. "Collared Scrub-Wren."
200. Orthonyx spinicauda. "Spine-tailed Log-runner."
201. Orthonyx spaldingi. "Black-headed Log-runner."
202. Cinclosoma punctatum "Spotted Ground-bird."
203. Cinclosoma castanonotum. "Chestnut-backed Ground-bird."
204. Cinclosoma cinnamoneum. "Cinnamon Ground-bird."
205. Cinclosoma castanothorax. "Chestnut-breasted Ground-bird."
206. Cinclosoma marginatum. "Northern or Black-vented Ground-bird."
206A. Pycnoptilus floccosus. "Pilot-bird."
207. Drymaœdus brunneopygius. "Scrub-Robin."
207A. Drymaœdus pallidus. "Pale Scrub-Robin."
208. Drymaœdus superciliaris. "Eastern Scrub-Robin."
209. Hylacola pyrrhopygia. "Chestnut-rumped Ground-Wren."
210. Hylacola cauta. "Red-rumped Ground-Wren."
211. Psophodes crepitans. "Coachwhip-bird."
212. Psophodes nigrogularis. "Black-throated Coachwhip-bird."
213. Pomatorhinus temporalis. "Babbler."

(1) Includes *C. magna*, *C. lincocapilla*, &c.
(2) Includes *S. gularis*, from Kent Group, Bass Straits.

214. Pomatorhinus superciliosus. "White-browed Babbler."
215. Pomatorhinus ruficeps. "Chestnut-crowned Babbler."
216. Pomatorhinus rubeculus. "Red-breasted Babbler."
217. Cinclorhamphus cruralis (1). "Brown Song-Lark."
218. Cinclorhamphus rufescens. "Rufous Song-Lark."
219. Calamanthus fuliginosus. "Striated Field-Wren."
220. Calamanthus campestris. "Field-Wren."
221. Calamanthus isabellinus. "Desert-Wren."
222. Ephthianura albifrons. "White-fronted Chat."
223. Ephthianura tricolor. "Tri-coloured Chat."
224. Ephthianura aurifrons. "Orange-fronted Chat."
225. Ephthianura crocea. "Yellow-breasted Chat."

FAMILY—PARIDÆ: "TIT-MICE."

SUB-FAMILY—PARINÆ.

226. Xerophila leucopsis. "White-face."
227. Xerophila pectoralis. "Chestnut-breasted White-face."
228. Xerophila nigricincta. "Black-banded White-face."
229. Sphenostoma cristatum. "Wedge-bill."

FAMILY—LANIIDÆ: "CROW-SHRIKES."

SUB-FAMILY—GYMNORHININÆ.

230. Gymnorhina tibicen. "Black-backed Magpie."
231. Gymnorhina leuconota. "White-backed Magpie."
232. Gymnorhina hyperleuca. "Lesser White-backed Magpie."
233. Gymnorhina dorsalis. "Long-billed Magpie."
234. Cracticus quoyi. "Black Butcher-bird."
235. Cracticus nigrigularis. "Black-throated Butcher-bird."
236 Cracticus picatus. "Pied Butcher-bird."
237. Cracticus leucopterus. "White-winged Butcher-bird."
238. Cracticus argenteus. "Silver-backed Butcher-bird."
239. Cracticus destructor. "Butcher-bird."
240. Cracticus cinereus. "Grey Butcher-bird."
241. Cracticus mentalis (spaldingi). "Spalding Butcher-bird."
242. Cracticus rufescens. "Rufous Butcher-bird."

SUB-FAMILY—PACHYCEPHALINÆ.

243. Falcunculus frontatus. "Yellow-bellied Shrike-Tit."
244. Falcunculus leucogaster. "White-bellied Shrike-Tit."
245. Oreoica cristata. "Bell-bird."
246. Eopsaltria australis. "Yellow-breasted Shrike-Robin."

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(1) Includes *C. cantillans*.

247. Eopsaltria magnirostris.(*) "Large-billed Shrike-Robin."
248. Eopsaltria chrysorhous. "Yellow-rumped Shrike-Robin."
249. Eopsaltria georgiana (griseogularis). "Grey-breasted Shrike-Robin."
250. Eopsaltria pulverulenta. "White-tailed Shrike-Robin."
251. Eopsaltria gularis (leucogaster). "White-breasted Shrike-Robin."
252. Heteromyias cinereifrons. "Ashy-fronted Fly-Robin."
253. Pachycephala melanura ([1]). "Black-tailed Thickhead."
254. Pachycephala gutturalis ([2]). "White-throated Thickhead."
255. Pachycephala occidentalis. "Western Thickhead."
256. Pachycephala glaucura. "Grey-tailed Thickhead."
257. Pachycephala falcata. "Northern Thickhead."
258. Pachycephala pallida. "Pale-breasted Thickhead."
259. Pachycephala rufiventris. "Rufous-breasted Thickhead."
260. Pachycephala gilberti. "Red-throated Thickhead."
261. Pachycephala olivacea. "Olive Thickhead."
262. Pachycephala simplex. "Brown Thickhead."
263. Pachycephala lanioides. "White-bellied Thickhead."
264. Pachycephala fretorum. "Torres Straits Thickhead."

FAMILY—CERTHIIDÆ:

SUB-FAMILY—CERTHIINÆ.

265. Climacteris melanura. "Black-tailed Tree-creeper."
266. Climacteris melanonotus. "Black-backed Tree-creeper."
267. Climacteris rufa. "Rufous Tree-creeper."
268. Climacteris leucophæa. "White-throated Tree-creeper."
269. Climacteris scandens. "Brown Tree-creeper."
270. Climacteris erythrops. "Red-browed Tree-creeper."
271. Climacteris superciliosa. "White-browed Tree-creeper."
271A. Climacteris pyrrhonota. "Red-backed Tree-creeper."

SUB-FAMILY—SITTINÆ.

272. Sittella chrysoptera. "Orange-winged Tree-runner."
273. Sittella leucocephala. "White-headed Tree-runner."
274. Sittella albata. "Pied Tree-runner."
375. Sittella pileata. "Black-capped Tree-runner."
276. Sittella tenuirostris. "Slender billed Tree-runner."
277. Sittella leucoptera. "White-winged Tree-runner."
278. Sittella striata. "Striated Tree-runner."

FAMILY—NECTARINIDÆ: "SUN-BIRDS."

279. Cinnyris (Nectarinia) frenata. "Sun-bird."

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* Same as *E. chrysorrhous.* ([1]) Includes *P. robusta.*
([2]) *P. rufogularis* is probably *P. gutturalis* in immature plumage.

FAMILY—MELIPHAGIDÆ: "HONEY-EATERS."

Sub-family—Myzomelinæ.

280. Myzomela sanguinolenta. "Sanguineous Honey-eater."
281. Myzomela erythrocephala. "Red-headed Honey-eater."
282. Myzomela nigra. "Black Honey-eater."
283. Myzomela pectoralis. "Banded Honey-eater."
284. Myzomela obscura. "Dusky Honey-eater."
285. Acanthorhynchus superciliosus. "Spine-bill."
286. Acanthorynchus tenuirostris (1). "White-browed Spine-bill."

Sub-family—Zosteropinæ.

287. Zosterops cœrulescens (2). "White-eye."
288. Zosterops ramsayi. "Yellow-vented White-eye."
289. Zosterops gouldi. "Green-backed White-eye."
290. Zosterops albiventer. "Pale-bellied White-eye."
291. Zosterops lutea. "Yellow White-eye."
292. Zosterops gulliveri. "Gulliver White-eye."
293. Melithreptus lunulatus. "White-naped Honey-eater."
294. Melithrephus chloropsis. "Western White-naped Honey-eater."
295. Melithreptus albigularis. "White-throated Honey-eater."
296. Melithreptus gularis. "Black-chinned Honey-eater."
297. Melithreptus validirostris. "Strong-billed Honey-eater."
298. Melithreptus brevirostris. "Brown-headed Honey-eater."
299. Melithreptus melanocephalus. "Black-headed Honey-eater."
300. Melithreptus lætior. "Golden-backed Honey-eater."
301. Melithreptus vinitinctus. "Gay Honey-eater."
302. Plectorhynchus lanceolatus. "Striped Honey-eater."

Sub-family—Meliphaginæ.

303. Glycyphila fulvifrons. "Tawny-crowned Honey-eater."
304. Glycyphila albifrons. "White-fronted Honey-eater."
305. Glycyphila fasciata. "White-breasted Honey-eater."
306. Glycyphila ocularis. "Brown Honey-eater."
307. Glycyphila subocularis. "Least Honey-eater."
308. Glycyphila modesta. "Brown-backed Honey-eater."
309. Glycyphila albiauricularis. "Broadbent Honey-eater."
310. Entomophila picta. "Painted Honey-eater."
311. Entomophila rufigularis. "Red-throated Honey-eater.
312. Entomophila albigularis. "Rufous-breasted Honey-eater."
313. Entomophila (Lichnotentha) leucomelas. "Pied Honey-eater."
314. Meliphaga phrygia. "Warty-faced Honey-eater."
315. Ptilotis analoga (notata). "Yellow-spotted Honey-eater."

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(1) Includes *A. dubius*. (2) Includes *Z. westernensis*.

316. Ptilotis gracilis. "Little Yellow-spotted Honey-eater."
317. Ptilotis fusca. "Fuscous Honey-eater."
318. Ptilotis lewini. "Yellow-eared Honey-eater."
319. Ptilotis frenata. "Bridled Honey-eater."
320. Ptilotis flavistriata. "Yellow-streaked Honey-eater."
321. Ptilotis sonora. "Singing Honey-eater."
322. Ptilotis versicolor (1). "Varied Honey-eater."
323. Ptilotis chrysops. "Yellow-faced Honey-eater."
324. Ptilotis filigera. "Streak-naped Honey-eater."
325. Ptilotis flavigularis. "Yellow-throated Honey-eater."
326. Ptilotis fasciogularis. "Fasciated Honey-eater."
327. Ptilotis leucotis. "White-eared Honey-eater."
328. Ptilotis cockerelli. "Cockerell Honey-eater."
329. Ptilotis auricomis. "Yellow-tufted Honey-eater."
330. Ptilotis cassidix. "Helmeted Honey-eater."
331. Ptilotis cratitia (2). "Wattle-cheeked Honey-eater."
332. Ptilotis keartlandi. "Keartland Honey-eater."
333. Ptilotis pencillata. "White-plumed Honey-eater."
334. Ptilotis ornata. "Yellow-plumed Honey-eater."
335. Ptilotis plumula. "Yellow-fronted Honey-eater."
336. Ptilotis flavescens (3). Yellow Honey-eater."
337. Ptilotis flava. "Yellow-tinted Honey-eater."
338. Ptilotis unicolor. "White-gaped Honey-eater."
339. Meliornis australasiana. "Crescent Honey-eater."
340. Meliornis novæ hollandiæ. "White-bearded Honey-eater."
341. Meliornis longirostris. "Long-billed Honey-eater."
342. Meliornis sericea. "White-cheeked Honey-eater."
343. Meliornis mystacalis. "Moustached Honey-eater."
344. Manorhina melanophrys. "Bell Minah."
345. Manorhina (Myzantha) garrula. "Noisy Minah."
346. Manorhina (Myzantha) obscura. "Dusky Minah."
347. Manorhina (Myzantha) flavigula. "Yellow-throated Minah.
348. Manorhina (Myzantha) lutea. "Yellow Minah."
349. Acanthochæra carunculata. "Yellow Wattle-bird."
350. Acanthochæra inauris. "Red Wattle-bird."
351. Acanthochæra (Anellobia) mellivora. "Brush Wattle-bird."
352. Acanthochæra (Anellobia) lunulata. "Little Wattle-bird."
353. Acanthochæra (Acanthogenys) rufigularis. "Spiney-cheeked Honey-eater."
354. Entomyza cyanotis. "Blue-faced Honey-eater."
355. Entomyza albipennis. "White-quilled Honey-eater."
356. Philemon corniculatus. "Friar-bird."
357. Philemon argenticeps. "Silvery-crowned Friar-bird."
358. Philemon buceroides. "Helmeted Friar-bird."

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(1) *P. macleayana.* (2) Includes *P. occidentalis.* (3) Includes *P. germana.*

359. Philemon citreogularis. "Yellow-throated Friar-bird."
360. Philemon sordidus. "Little Friar-bird."
361. Philemon occidentalis. "Western Friar-bird."

FAMILY—DICÆIDÆ: "FLOWER-PECKERS."

362. Dicæum hirundinaceum. "Flower-pecker or Mistletoe-bird."
363. Pardalotus ornatus (striatus). "Red-tipped Pardalote."
364. Pardalotus assimilis. "Orange-tipped Pardalote."
365. Pardalotus affinis. "Yellow-tipped Pardalote."
366. Pardalotus punctatus. "Spotted Pardalote." (Diamond-bird.)
367. Pardalotus xanthopygius. "Yellow-rumped Pardalote."
368. Pardalotus rubricatus. "Red-browed Pardalote."
369. Pardalotus melanocephalus. "Black-headed Pardalote."
370. Pardolatus uropygialis. "Chestnut-rumped Pardalote."
371. Pardalotus guadragintus. "Forty-spotted Pardalote."

FAMILY—HIRUNDINIDÆ: "SWALLOWS."

SUB-FAMILY—HIRUNDININÆ: "SWALLOWS PROPER."

372. Hirundo javanica. "Eastern Swallow."
373. Hirundo neoxena (frontalis). "Swallow."
374. Cheramœca leucosternum. "Black and White Swallow."
375. Petrochelidon nigricans. "Tree Martin."
376. Petrochelidon (Lagenoplastes) ariel. "Fairy Martin."

FAMILY—MOTACILLIDÆ: "WAGTAILS AND PIPITS."

377. Anthus australis. "Pipit." "Ground-lark."

FAMILY—ARTAMIDÆ: "WOOD-SWALLOWS."

378. Artamus leucogaster. "White-rumped Wood-Swallow."
379. Artamus superciliosus. "White-browed Wood-Swallow."
380. Artamus personatus. "Masked Wood-Swallow."
381. Artamus cinereus. "Grey-breasted Wood-Swallow."
382. Artamus hypoleucus. "White-bellied Wood-Swallow."
383. Artamus melanops. "Black-faced Wood-Swallow."
384. Artamus sordidus. "Wood-Swallow."
385. Artamus minor. "Little Wood-Swallow."
386. Artamus venustus (1). "White-vented Wood-Swallow."

FAMILY—STURNIDÆ: "STARLINGS."

SUB-FAMILY—STURNINÆ.

387. Calornis metallica. "Shining Starling."

(1) Considered by some authorities to be *A. cinereus*.

FAMILY—PLOCEIDÆ: "WEAVERS."

Sub-family—Viduinæ.

388. Staganopleura guttata. "Spotted-sided Finch."
389. Zonæginthus bellus. "Fire-tailed Finch."
390. Zonæginthus oculatus. "Red-eared Finch."
391. Emblema picta. "Painted Finch."
392. Tæniopygia castanotis. "Chestnut-eared Finch."
393. Stictoptera bichenovii. "Banded Finch."
394. Stictoptera annulosa. "Black-ringed Finch."
395. Munia castaneithorax. "Chestnut-breasted Finch."
396. Munia flaviprymna. "Yellow-rumped Finch."
397. Munia pectoralis. "White-breasted Finch."
398. Aidemosyne modesta. "Plum-head Finch."
399. Ægintha temporalis. "Red-browed Finch."
400. Bathilda ruficanda. "Red-faced Finch."
401. Poephila acuticauda. "Long-tailed Finch."
402. Poephila cincta. "Black-throated Finch."
403. Poephila personata. "Masked Finch."
404. Poephila leucotis. "White-eared Finch."
405. Poephila atropygialis. "Black-rumped Finch."
406. Poephila gouldiæ. "Gouldian Finch."
407. Poephila mirabilis. "Scarlet-headed Finch."
408. Neochmia phaeton. "Crimson Finch."

FAMILY—ALAUDIDÆ: "LARKS."

409. Mirafra horsfieldi. "Bush-Lark."
410. Mirafra secunda. "Lesser Bush-Lark."

FAMILY—ATRICHIIDÆ: "SCRUB-BIRDS."

411. Atrichia clamosa. "Noisy Scrub-bird."
412. Atrichia rufescens. "Rufous Scrub-bird."

FAMILY—MENURIDÆ: "LYRE-BIRDS."

413. Menura superba. "Lyre-bird."
414. Menura victoriæ. "Victoria Lyre-bird."
415. Menura alberti. "Albert Lyre-bird."

FAMILY—PITTIDÆ: "ANT-THRUSHES."

416. Pitta strepitans [1]. "Noisy Pitta."
417. Pitta mackloti. "Blue-breasted Pitta."
418. Pitta iris. "Rainbow Pitta."

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(1) Includes *P. simillima.*

ORDER.—PICARIÆ: "PICARIAN BIRDS."

Sub-order—Coraciæ.

FAMILY—CYPSELIDÆ: "SWIFTS."

SUB-FAMILY—CYPSELINÆ.

419. Micropus (Cypselus) pacificus. "White-rumped Swift."

SUB-FAMILY—CHAETURINÆ.

420. Chætura caudacuta. "Spine-tailed Swift."
421. Callocalia francica. "Grey-rumped Swiftlet."
422. Callocalia esculenta. "Edible-nest Swiftlet."

FAMILY—CAPRIMULGIDÆ: "GOAT-SUCKERS."

SUB-FAMILY: CAPRIMULGINÆ.

423. Caprimulgus macrurus. "Large-tailed Nightjar."
424. Eurostopus albigularis. "White-throated Nightjar."
425. Eurostopus argus (guttatus). "Spotted Nightjar."

FAMILY—PODARGIDÆ.

SUB-FAMILY—PODARGINÆ.

426. Podargus papuensis (1). "Plumed Frogmouth."
427. Podargus strigoides (2). "Tawny Frogmouth."
428. Podargus phalænoides (3). "Freckled Frogmouth."
429. Podargus marmoratus. "Marbled Frogmouth."

SUB-FAMILY—ÆGOTHELINÆ.

430. Ægotheles novæ-hollandiæ (4). "Owlet Nightjar."

FAMILY—CORACIIDÆ: "ROLLERS."

SUB-FAMILY—CORACIINÆ.

431. Eurystomus australis. "Roller or Dollar-bird."

FAMILY—MEROPIDÆ: "BEE-EATERS."

432. Merops ornatus. "Bee-eater."

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(1) Includes *P. plumiferus*. (2) Includes *P. cuvieri* and *P. megacephalus*.
(3) Includes *P. brachypterus*. (4) Includes *Æ. leucogaster*.

Sub-order—Halcyones.

FAMILY—ALCEDINIDÆ: "KINGFISHERS."

SUB-FAMILY—ALCEDININÆ.

433. Alcyone azurea ([1]). "Blue Kingfisher."
434. Alcyone pulchra. "Purple Kingfisher."
435. Alcyone pusilla. "Little Kingfisher."

SUB-FAMILY—DACELONINÆ.

436. Syma flavirostris. "Yellow-billed Kingfisher."
437. Dacelo gigas. "Brown Kingfisher" (Laughing Jackass).
438. Dacelo leachii. "Leach Kingfisher."
439. Dacelo cervina ([2]). "Fawn-breasted Kingfisher."
440. Halcyon macleayi. "Forest Kingfisher."
441. Halcyon pyrrhopygius. "Red-backed Kingfisher."
442. Halcyon sanctus. "Sacred Kingfisher."
443. Halcyon sordidus. "Mangrove Kingfisher."
444. Tanysiptera sylvia. "White-tailed Kingfisher."

Sub-order—Coccyges: "Cuckoos," &c.

FAMILY—CUCULIDÆ: "CUCKOOS."

SUB-FAMILY—CUCULINÆ.

445. Cuculus intermedius (canoroides). "Oriental Cuckoo."
446. Cuculus pallidus. "Pallid Cuckoo."
447. Cacomantis flabelliformis. "Fan-tailed Cuckoo."
448. Cacomantis variolosus ([3]). "Square-tailed (Brush) Cuckoo."
449. Cacomantis castaneiventris. "Chestnut-breasted Cuckoo."
450. Mesocalius palliolatus (osculaus). "Black-eared Cuckoo."
451. Chalcococcyx basalis. "Narrow-billed Bronze-Cuckoo."
452. Chalcococcyx lucidus. "Broad-billed Bronze-Cuckoo."
453. Chalcococcyx plagosus. "Bronze-Cuckoo."
454. Chalcococcyx malayanus (minutillus) ([4]). "Little Bronze-Cuckoo."
455. Chalcococcyx pœcilurus. "Rufous-throated Bronze-Cuckoo."
456. Eudynamis cyanocephala (flindersi). "Koel."
457. Scythrops novæ-hollandiæ. "Channel-bill."

SUB-FAMILY—CENTROPODINÆ.

458. Centropus phasianus ([5]). "Coucal."

([1]) Includes *A. diemenensis*. ([2]) Includes *D. occidentalis*.
([3]) Includes *C. insperatus* and *C. dumetorum*. ([4]) Includes *C. russatus*.
([5]) Includes *C. macrourus* and *C. melanurus*.

ORDER—PSITTACI: "PARROTS."

FAMILY—LORIIDÆ: "LORIES, OR BRUSH-TONGUED PARROTS."

459. Trichoglossus novæ-hollandiæ (multicolor).(1) "Blue-bellied Lorikeet."
460. Trichoglossus rubritorquis. "Red-collared Lorikeet."
461. Psittenteles chlorolepidotus. "Scaly-breasted Lorikeet."
462. Ptilosclera versicolor. "Varied Lorikeet."
463. Glossopsittacus concinnus (australis). "Musk Lorikeet."
464. Glossopsittacus porphyrocephalus. "Purple-crowned Lorikeet."
465. Glossopsittacus pusillus. "Little Lorikeet."

FAMILY—CYCLOPSITTACIDÆ:

466. Cyclopsittacus coxeni. "Red-faced Lorilet."
467. Cyclopsittacus maccoyi. "Blue-faced Lorilet."

FAMILY—CACATUIDÆ: "COCKATOOS."

SUB-FAMILY—CACATUINÆ.

468. Microglossus aterrimus. "Palm Cockatoo."
469. Calyptorhynchus baudini. "White-tailed Cockatoo."
470. Calyptorhynchus funereus. (2) "Black Cockatoo."
471. Calyptorhynchus banksi. "Banksian Cockatoo."
472. Calyptorhynchus macrorhynchus. "Great-billed Cockatoo."
473. Calyptorhynchus stellatus (naso). "Red-tailed Cockatoo."
474. Calyptorhynchus viridis (leachii). "Glossy Cockatoo."
475. Callocephalon galeatum. "Gang-Gang Cockatoo."
476. Cacatua galerita. "White Cockatoo."
477. Cacatua leadbeateri. "Pink Cockatoo."
478. Cacatua gymnopis. "Bare-eyed Cockatoo."
479. Cacatua sanguinea. "Blood-stained Cockatoo."
480. Cacatua roseicapilla. "Rose-breasted Cockatoo" (Galah).
481. Licmetis nasica. "Long-billed Cockatoo" (Corella).
482. Licmetis pastinator. "Dampier Cockatoo."

SUB-FAMILY—CALOPSITTACINÆ:

483. Calopsittacus novæ-hollandiæ. "Cockatoo Parrakeet."

FAMILY—PSITTACIDÆ: PARROTS.

SUB-FAMILY—PALÆORNITHINÆ:

484. Polytelis barrabandi. "Green-Leek Parrakeet."
485. Polytelis alexandræ. "Alexandra Parrakeet."

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(1) *T. verreauxius*, given in some works, may be a hybrid. (2) Includes *C. xanothonotus*.

486. Polytelis melanura. "Black-tailed Parrakeet" (Rock-Pebbler).
487. Ptistes erythropterus. "Red-winged Lory."
488. Ptistes coccineopterus. "Crimson-winged Lory."
489. Aprosmictus cyanopygius. "King Lory."

SUB-FAMILY—PLATYCERCINÆ: "PARRAKEETS."

490. Platycercus elegans (pennantii). "Crimson Parrakeet."
491. Platycercus mastersianus. "Masters Parrakeet."
492. Platycercus nigrescens. "Campbell Parrakeet."
493. Platycercus adelaidæ. "Adelaide Rosella."
494. Platycercus flaveolus. "Yellow Parrakeet."
495. Platycercus flaviventris. "Green Parrakeet."
496. Platycercus pallidiceps. "Pale-headed Parrakeet."
497. Platycercus amathusia. "Blue-cheeked Parrakeet."
498. Platycercus browni (venustus). "Smutty Parrakeet."
499. Platycercus erythropeplus. "Red-backed Rosella."
500. Platycercus eximius. "Rosella."
501. Platycercus splendidus. "Yellow-mantled Parrakeet."
502. Platycercus ignitus. "Fiery Parrakeet."
503. Platycercus icterotis. "Yellow-cheeked Parrakeet."
504. Platycercus xanthogenys. (1) "Red-mantled Parrakeet."
505. Porphyrocephalus spurius (pileatus). "Red-capped Parrakeet."
506. Barnardius (Platycercus) barnardi. "Mallee Parrakeet."
507. Barnardius (Platycercus) semitorquatus. "Yellow-collared Parrakeet."
508. Barnardius (Platycercus) zonarius. "Yellow-banded Parrakeet."
509. Psephotus hæmatorrhous. "Crimson-bellied Parrakeet."
510. Psephotus xanthorrhous. "Yellow-vented Parrakeet."
511. Psephotus pallescens.
512. Psephotus pulcherrmus. "Beautiful Parrakeet."
513. Psephotus chrysopterygius. "Golden-shouldered Parrakeet."
514. Psephotus multicolor. "Many-coloured Parrakeet."
515. Psephotus hæmatonotus. "Red-backed Parrakeet."
516. Neophema bourkei. "Bourke Grass-Parrakeet."
517. Neophema venusta (aurantia). "Blue-winged Grass-Parrakeet."
518. Neophema elegans. "Grass-Parrakeet."
519. Neophema chrysogastra. "Orange-bellied Grass-Parrakeet."
520. Neophema petrophila. "Rock Parrakeet."
521. Neophema pulchella. "Red-shouldered Grass-Parrakeet."
522. Neophema splendida. "Orange-throated Grass-Parrakeet."
523. Nanodes discolor. "Swift Lorikeet."

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(1) Allied to *P. icterotis*. Habitat unknown.

524. Melopsittacus undulatus. "Betcherrygah," or "Warbling Grass-Parrakeet."
525. Pezoporus formosus. "Ground Parrakeet."
526. Geopsittacus occidentalis. "Night Parrakeet."

ORDER—COLUMBÆ: "PIGEONS AND DOVES."

Sub-order—Columbæ: "Pigeons."

FAMILY—TRERONIDÆ.

SUB-FAMILY—PTILOPODINÆ.

527. Ptilopus swainsoni. "Red-crowned Fruit-Pigeon."
528. Ptilopus ewingi. "Rose-crowned Fruit-Pigeon."
529. Lamprotreron superbus. "Purple-crowned Fruit-Pigeon."
530. Megaloprepia magnifica. "Purple-breasted Fruit-Pigeon."
531. Megaloprepia assimilis. "Allied Fruit-Pigeon."

SUB-FAMILY—CARPOPHAGINÆ.

532. Myristicivora spilorrhoa. "Nutmeg Pigeon."
533. Lopholæmus antarcticus. "Topknot Pigeon."

FAMILY—COLUMBIDÆ.

SUB-FAMILY—COLUMBINÆ.

534. Columba leucomela (norfolciensis). "White-headed Fruit-Pigeon."

SUB-FAMILY—MACROPYGIINÆ.

535. Macropygia phasianella. "Pheasant-tailed Pigeon."

FAMILY—PERISTERIDÆ.

SUB-FAMILY—GEOPELINÆ.

536. Geopelia humeralis. "Barred-shouldered Dove."
537. Geopelia tranquilla [1]. "Ground Dove."
538. Geopelia cuneata. "Little Dove."

SUB-FAMILY—PHABINÆ.

539. Chalcophaps chrysochlora [2]. "Little Green-Pigeon."
540. Phaps chalcoptera. "Bronze-wing."
541. Phaps elegans. "Brush Bronze-wing."
542. Histriophaps histrionica. "Flock Pigeon."
543. Petrophassa albipennis. "Rock Pigeon."
544. Geophaps scripta. "Partridge Pigeon."
545. Geophaps smithi. "Naked-eyed Partridge-Pigeon."
546. Lophophaps plumifera. "Plumed Pigeon."

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(1) Includes *C. placida*. (2) Includes *C. longirostris*.

547. Lophophaps ferruginea. "Red Plumed-Pigeon."
548. Lophophaps leucogaster. "White-bellied Plumed-Pigeon."
549. Ocyphaps lophotes. "Crested Pigeon."

SUB-FAMILY—GEOTRYGONINÆ.

550. Leucosarcia picata. "Wonga-Wonga Pigeon."

ORDER—GALLINÆ: "GAME-BIRDS."

Sub-order—Alectoropodes.

FAMILY—PHASIANIDÆ: "PHEASANTS, &c."

551. Coturnix pectoralis. "Stubble Quail."
552. Synœcus australis ([1]) "Brown Quail."
553. Excalfactoria lineata (australis). "Chestnut-bellied Quail."

Sub-order—Peristeropodes.

FAMILY—MEGAPODIIDÆ: "MEGAPODES."

554. Megapodius duperreyi (tumulus). "Scrub Fowl."
555. Lipoa ocellata. "Mallee Fowl." (Native Pheasant.)
556. Catheturus (Talegallus) lathami. "Brush Turkey."
557. Catheturus purpureicollis. "Barnard Brush-Turkey."

ORDER—HEMIPODII: "HEMIPODES."

FAMILY—TURNICIDÆ: "HEMIPODES."

558. Turnix maculosa (melanotus). "Red-backed Quail.'
559. Turnix melanogaster. "Black-breasted Quail."
560. Turnix varia ([2]). "Painted Quail."
561. Turnix castanonota. "Chestnut-backed Quail."
562. Turnix pyrrhothorax. "Red-chested Quail."
563. Turnix velox. "Little Quail."
564. Turnix leucogaster. "White-bellied Quail."
565. Pedionomus torquatus. "Plain Wanderer."

ORDER—FULICARIÆ.

FAMILY—RALLIDÆ: "RAILS."

566. Hypotænidia (Rallus) brachypus. "Slate-breasted Rail."
567. Hypotænidia philippinensis. "Pectoral Rail."
568. Eulabeornis castaneiventris. "Chestnut-bellied Rail."
569. Rallina tricolor. "Red-necked Rail."
570. Crex crex ([3]). "Corn Crake."
571. Porzana fluminea. "Spotted Crake."
572. Porzana palustris. "Little Crake."

([1]) Includes *T. diemenensis*, *S. sordidus*, and *S. cervinus*. ([2]) Includes *T. scintillans*.
([3]) A single specimen was obtained near Sydney, June, 1893.

573. Porzana tabuensis. "Spotless Crake."
574. Poliolimnas (Erythra) cinereus (quadristrigata). "White-browed Crake."
575. Amaurornis moluccana ([1]). "Rufous-tailed Moor-hen."
576. Tribonyx mortieri. "Native-hen."
577. Microtribonyx ventralis. "Black-tailed Native-hen."
578. Gallinula tenebrosa. "Black Moor-hen."
579. Porphyrio bellus. "Blue Bald-Coot."
580. Porphyrio melanonotus. "Bald-Coot."
581. Fulica australis. "Coot."

ORDER—ALECTORIDES.

FAMILY—GRUIDÆ: "CRANES."

582. Antigone australasiana. "Crane," or "Native Companion."

FAMILY—OTIDIDÆ: "BUSTARDS."

583. Eupodotis australis. "Bustard," or "Wild Turkey."

ORDER—LIMICOLÆ: "PLOVERS, &c."

FAMILY—ŒDICNEMIDÆ: "THICK-KNEES."

584. Burhinus (Œdicnemus) grallarius. "Stone Plover."
585. Orthorhamphus (Esacus) magnirostris. "Long-billed Stone-Plover."

FAMILY—CURSORIIDÆ: "COURSERS."

586. Stiltia (Glareola) isabella (grallaria). "Pratincole."
587. Glareola orientalis. "Oriental Pratincole."

FAMILY—PARRIDÆ: "PARRAS."

588. Hydralector (Parra) gallinaceus. "Comb-crested Jacana."

FAMILY—CHARADRIIDÆ: "PLOVERS."

SUB-FAMILY—ARENARIINÆ.

589. Arenaria (strepsilas) interpres. "Turnstone."

SUB-FAMILY—HÆMATOPODINÆ: "OYSTER-CATCHERS."

590. Hæmatopus longirostris. "Pied Oyster-catcher."
591. Hæmatopus unicolor ([2]). "Black Oyster-catcher."

SUB-FAMILY—LOBIVANELLINÆ.

592. Erythrogonys cinctus. "Red-kneed Dottrel."
593. Lobivanellus lobatus. "Spur-winged Plover."
594. Lobivanellus miles. "Masked Plover."

([1]) *Gallinula ruficrissa.* ([2]) Includes *H. ophthalmicus.*

Sub-family—Charadriinæ.

595. Zonifer (Sarciophorus) tricolor (pectoralis). "Black-breasted Plover."
596. Squatarola helvetica. "Grey Plover."
597. Charadrius dominicus (fulvus). "Lesser Golden Plover."
598. Ochthodromus bicinctus. "Double-banded Dottrel."
599. Ochthodromus veredus. "Oriental Dottrel."
600. Ochthodromus geoffroyi. "Large Sand-Dottrel."
601. Ochthodromus mongolus(1). "Mongolian Sand-Dottrel."
602. Ægialitis hiaticola. "Ringed Dottrel."
603. Ægialitis ruficapilla. "Red-capped Dottrel."
604. Ægialitis melanops (nigrifrons). "Black-fronted Dottrel."
605. Ægialitis cucullata (monacha). "Hooded Dottrel."

Sub-family—Peltohyatinæ.

606. Peltohyas (Eudromias) australis. "Dottrel."

Sub-family—Himantopodinæ: "Stilts, &c."

607. Himantopus leucocephalus. "White-headed Stilt."
608. Cladorhyncus leucocephalus. "Banded Stilt."
609. Recurvirostra novæ hollandiæ. "Red-necked Avocet."

Sub-family—Totaninæ.

610. Numenius cyanopus. "Curlew."
611. Numenius variegatus. "Whimbrel."
612. Mesoscolopax minutus. "Little Whimbrel."
613. Limosa novæ zealandiæ. "Barred-rumped Godwit."
614. Limosa limosa (melanuroides). "Black-tailed Godwit."
615. Totanus stagnatilis. "Little Greenshank."
616. Hecteractitis brevipes. "Grey-rumped Sandpiper."
617. Hecteractitis incanus. "American Grey-rumped Sandpiper."
618. Tringoides hypoleucus. "Common Sandpiper."
619. Terekia cinerea. "Terek Sandpiper."
620. Glottis nebularius (glottoides). "Greenshank."
621. Bartramia longicauda. "Bartram Sandpiper."

Sub-family—Scolopacinæ: "Snipes."

622. Calidris arenaria. "Sanderling."
623. Limonites ruficollis. "Little Stint."
624. Heteropygia acuminata. "Sharp-tailed Stint."
625. Ancylochilus subarquatus. "Curlew Stint."
626. Tringa canutus. "Knot."
627. Tringa crassirostris. "Great Sandpiper."
628. Gallinago australis. "Snipe."
629. Rostratula (Rhynchæa) australis. "Painted Snipe."

(1) Includes *Ægialitis mastersi.*

ORDER—GAVIÆ: "SEA-BIRDS."

FAMILY—LARIDÆ: "GULLS AND TERNS."

SUB-FAMILY—STERNINÆ: "TERNS."

630. Hydrochelidon leucoptera (1). "White-winged Tern."
631. Hydrochelidon hybrida. "Marsh Tern."
632. Gelochelidon anglica (macrotarsa). "Gull-billed Tern."
633. Hydroprogne caspia. "Caspian Tern."
634. Sterna dougalli (2) (gracilis). "Roseate Tern."
635. Sterna media. "Lesser Crested Tern."
636. Sterna bergii (3). "Crested Tern."
637. Sterna frontalis. "White-fronted Tern."
638. Sterna anæstheta. "Brown-winged Tern."
639. Sterna fuliginosa. "Sooty Tern."
640. Sterna nereis (4). "White-faced Ternlet."
641. Sterna sinensis. "White-shafted Ternlet."
642. Sterna melanauchen. "Black-naped Tern."
643. Procelsterna cinerea. "Grey Noddy."
644. Anous stolidus. "Noddy."
645. Micranous tenuirostris. "Lesser Noddy."
646. Micranous leucocapillus. "White-capped Noddy."
647. Gygis candida. "White Tern."

SUB-FAMILY—LARINÆ: "GULLS."

648. Larus novæ hollandiæ (5). "Silver Gull."
649. Gabianus (Larus) pacificus. "Pacific Gull."

SUB-FAMILY—STERCORARIIDÆ: "SKUAS."

650. Megalestris antartica. "Skua."
651. Stercorarius pomatorhinus. "Pomarine Skua."
652. Stercorarius crepidatus. "Richardson Skua."

ORDER—TUBINARES: "TUBE-NOSED SWIMMERS."

FAMILY—PROCELLARIIDÆ: "PETRELS."

SUB-FAMILY—OCEANITINÆ: "STORM PETRELS."

653. Oceanites oceanicus. "Yellow-webbed Storm-Petrel."
654. Garrodia nereis. "Grey-backed Storm-Petrel."
655. Pelagodroma marina (fregata). "White-faced Storm-Petrel.'
656. Cymodroma melanogaster. "Black-bellied Storm-Petrel."
657. Cymodroma grallaria. "White-bellied Storm-Petrel."

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(1) It is doubtful whether this species should be included.
(2) Includes *S. nigrifrons*. (3) Includes *Thalasseus cristatus* and *T. poliocercus*.
(4) Includes *S. inconspicua*. (5) Includes *L. gouldi* and *L. longirostris*.

FAMILY—PUFFINIDÆ: "PETRELS &c."

Sub-family—Puffininæ.

658. Puffinus chlororhynchus (sphenurus). "Wedge-tailed Petrel."
659. Puffinis assimilis (nugax). "Allied Petrel."
660. Puffinus carneipes. "Fleshy-footed Petrel."
661. Puffinus tenuirostris (brevicandus). "Short-tailed Petrel (Mutton-bird)."
662. Puffinus leucomelas. "White-fronted Petrel."
663. Puffinus griseus. "Sombre Petrel."
664. Puffinus gavia. "Forster Petrel."
665. Priofinus (Adamastor) cinereus. "Brown Petrel."
666. Priocella glacialoides. "Silver-grey Petrel."
667. Majaqueus æquinoctialis (conspicillatus). "Spectacled Petrel."
668. Majaqueus parkinsoni. "Black Petrel."
669. Œstrelata macroptera. "Great-winged Petrel."
670. Œstrelata lessoni (leucocephala). "White-headed Petrel."
671. Œstrelata mollis. "Soft-plumaged Petrel."
672. Œstrelata solandri. "Brown-headed Petrel."
673. Œstrelata leucoptera (1). "White-winged Petrel."
674. Œstrelata cooki. "Cook Petrel."
675. Œstrelata rostrata. "Peale Petrel."

Sub-family—Fulmarinæ: "Fulmars."

676. Ossifraga gigantea. "Giant Petrel."
677. Daption capensis. "Cape Petrel."
678. Halobæna cærulea. "Blue Petrel."
679. Prion vittatus. "Broad-billed Dove-Petrel, or Prion."
680. Prion banksi. "Banks Dove-Petrel, or Prion."
681. Prion desolatus (turtur). "Dove-Petrel, or Prion."
682. Prion ariel. "Fairy Dove-Petrel, or Prion."

FAMILY—PELECANOIDIDÆ.

683. Pelecanoides urinatrix. "Diving Petrel."

FAMILY—DIOMEDEIDÆ: "ALBATROSSES."

684. Diomedea exulans. "Wandering Albatross."
685. Diomedea albatrus (brachyura). "Short-tailed Albatross."
686. Diomedea melanophrys. "Black-browed Albatross" (Mollyhawk).
687. Thalassogeron cautus. "White-capped Albatross."

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(1) Includes *Pterodroma atlantica.*

688. Thalassogeron culminatus. "Flat-billed Albatross."
689. Thalassogeron chlororhynchus. "Yellow-nosed Albatross."
690. Phœbetria fuliginosa. "Sooty Albatross."

ORDER—HERODIONES: "HERONS."

FAMILY—PLATALEIDÆ: "SPOONBILLS."

691. Geronticus (Carphibis) spinicollis. "Straw-necked Ibis."
692. Threskiornis strictipennis. "White Ibis."
693. Ibis falcinellus. "Glossy Ibis."
694. Platalea regia. "Black-billed Spoonbill."
695. Platalea flavipes. "Yellow-billed Spoonbill."

FAMILY—CICONIIDÆ: "STORKS."

696. Xenorhynchus asiaticus. "Black-necked Stork" (Jabiru).

FAMILY—ARDEIDÆ: "HERONS PROPER."

697. Ardea cinerea. "Grey Heron."
698. Ardea sumatrana. "Great-billed Heron."
699. Ardea pacifica. "White-necked Heron."
700. Ardea novæ hollandiæ. "White-fronted Heron."
701. Herodias alba. "White Egret."
702. Herodias intermedia (egrettoides). "Plumed Egret."
703. Herodias melanopus. "Lesser Egret."
704. Herodias garzetta. "Little Egret."
705. Demiegretta asha. "Ashy or Sombre Reef-Heron."
706. Demiegretta picata. "Pied Egret."
707. Demiegretta sacra (1). "Reef Heron."
708. Nycticorax caledonicus. "Night Heron."
709. Botaurus poicilopterus. "Bittern."
710. Butoroides flavicollis. "Black Bittern."
711. Butoroides macrorhyncha. "Thick-billed Bittern."
712. Butoroides javanica. "Green Bittern."
713. Ardetta minuta (pusilla). "Little Bittern."

ORDER—STEGANOPODES: "PELICANS."

FAMILY—PELICANIDÆ: "PELICANS."

714. Pelecanus conspicillatus. "Pelican."

FAMILY—PLOTIDÆ: "DARTERS."

715. Plotus novæ hollandiæ "Darter."

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(1) Includes *D. jugularis* and *D. greyi.*

FAMILY—PHALACORCORACIDÆ: "CORMORANTS."

716. Phalacrocorax novæ hollandiæ. "Black Cormorant."
717. Phalacorcorax varius. "Pied Cormorant."
718. Phalacorcorax leucogaster. "White-breasted Cormorant."
719. Phalacorcorax melanoleucus. "Little Cormorant."
720. Phalacorcorax strictocephalus. "Little Black Cormorant."

FAMILY—FREGATIDÆ: "FRIGATE-BIRDS."

722. Tachypetes aquila. "Frigate-bird."
723. Tachypetes minor. "Lesser Frigate-bird."

FAMILY—PHÆTHONTIDÆ: "TROPIC-BIRDS."

724. Phaëton rubricauda. "Red-tailed Tropic-bird."
725. Phaëton candidus. "White-tailed Tropic-bird."

FAMILY—SULIDÆ: "GANNETS."

726. Sula serrator (australis). "Gannet."
727. Sula cyanops. "Masked Gannet."
728. Sula leucogastra (fiber). "Brown Gannet" (Booby).
729. Sula piscator. "Red-legged Gannet."

ORDER—PYGOPODES: "DIVING-BIRDS."

FAMILY—PODICIPEDIDÆ: "GREBES."

730. Podiceps cristatus. "Tippet Grebe."
731. Podiceps nestor. "Hoary-headed Grebe."
732. Podiceps novæ hollandiæ. "Black-throated Grebe."

ORDER—IMPENNES: "PENGUINS."

FAMILY—SPHENISCIDÆ.

733. Catarractes chrysocome. "Crested Penguin."
734. Eudyptula minor. "Little Penguin."
735. Eudyptula undina. "Fairy Penguin."

ORDER—CHENOMORPHÆ.

SUB-ORDER—ANSERES: "GEESE," &c.

FAMILY—ANATIDÆ: "DUCKS."

SUB-FAMILY—CYGNINÆ: "SWANS."

736. Chenopis atrata. "Black Swan."

Sub-family—Anseranatinæ.

737. Anseranas semipalmata. "Pied Goose."

Sub-family—Plectropterinæ.

738. Nettopus pulchellus. "Green Goose-Teal."
739. Nettopus albipennis. "White-quilled Goose-Teal."

Sub-family—Cereopsinæ.

740. Cereopsis novæ hollandiæ. "Cape Barren Goose."

Sub-family—Chenonettinæ

741. Chenonetta (Chlamydochen) jubata. "Wood Duck or Maned Goose."

Sub-family—Anatinæ.

742. Dendrocycna arcuata (gouldi). "Whistling-Duck."
743. Dendrocycna eytoni. "Plumed Whistling-Duck."
744. Tadorna radjah. "White-headed Shieldrake."
745. Casarca tadornoides. "Shieldrake or Mountain Duck."
746. Anas superciliosa. "Black Duck."
747. Nettion (Anas) castaneum (punctata). "Teal."
748. Nettion (Anas) gibberifrons. "Grey Teal."
749. Spatula clypeata. "Common Shoveller."
750. Spatula rhynchotis "Shoveller" (Blue-wing).
751. Malacorhynchus membranaceus. "Pink-eared Duck" (Widgeon).
752. Stictonetta nævosa. "Freckled Duck."

Sub-family—Fuligulinæ.

753. Nyroca australis. "White-eyed Duck" (Hardhead)

Sub-family—Erismaturinæ.

754. Erismatura australis. "Blue-billed Duck."
755. Biziura lobata. "Musk Duck."

Sub-class—Ratitæ: "Struthious Birds."

ORDER—CASUARII.

FAMILY DROMÆIDÆ: "EMUS."

756. Dromæus novæ hollandiæ. "Emu."
757. Dromæus irroratus. "Spotted Emu."
758. Dromæus ater. (Extinct.)

FAMILY—CASUARIIDÆ: "CASSOWARIES."

759. Casuarius australis. "Cassowary."

PROCEEDINGS OF THE SECTIONS.

PROCEEDINGS OF THE SECTIONS.

SECTION A.

ASTRONOMY, MATHEMATICS, AND PHYSICS.

PRESIDENTIAL ADDRESS.

By P. BARACCHI, F.R.A.S., Government Astronomer, Melbourne.

(Delivered Friday, January 7, 1898.*)*

ASTRONOMY and terrestrial physics are, among others, branches of knowledge for the advancement of which it is necessary that every civilised country should contribute its share of scientific activity. The study of astronomy embraces the entire vault of the heavens, and the physical conditions of our terrestrial globe can only be fully investigated by the observation and interpretation of phenomena occurring over the whole extent of its surface.

In these respects, the isolated position of our colonies in the Southern Hemisphere imposes upon us the responsibility of obtaining and supplying data for the progress and completion of general researches and undertakings in which the rest of the world has already done, or is doing, its part. We have not been idle, and looking back on the scientific work and enterprise of these colonies in the past we may, not unnaturally, feel inclined to think that we have done a great deal in a short space of time and among the distracting influences and first necessities of colonial development; but if we consider what yet remains to be done, in view of modern requirements, and in order to be able to reach, and keep pace with, the more advanced workers, most of us will feel oppressed and perplexed by the innumerable demands that will be made upon us in the immediate future.

Of these demands, even of the most important of them, it is well to be conscious that we can only attempt to satisfy a few, and for this reason it becomes necessary from time to time to decide as to their relative urgency in order to concentrate our efforts in the accomplishment of what seems most desirable according to circumstances.

With this end in view I propose to point out in this address certain branches of astronomy and terrestrial physics which, in my opinion, have the strongest claim to the immediate consideration of the scientific workers of the Australasian colonies and, in some cases, to the encouragement and support of their Governments.

In astronomy, as practised in Australia, it is necessary to distinguish the work of the fixed Observatories, maintained at the public expense, from that of the private or amateur astronomers.

The National Observatories, of which there are four in Australia, namely, Sydney, Melbourne, Adelaide, and Perth—this last having just been established—equipped as they are with fine instruments, modern apparatus and appliances of the best workmanship attainable, with their staff of assistants, their extensive libraries, their financial resources, and their facility of communication with the scientific world, possess the best conditions for carrying on work of a fundamental character, methodically continued from day to day, and from year to year, on a relatively large scale, with the highest degree of precision attainable with the most perfect means, for the gradual but steady accumulation of long series of observations and records intended to serve the purposes of working astronomers of the present and of the future, or to form a part of general undertakings in co-operation with other Observatories of the world.

Such, in fact, is the nature of our main contribution to astronomy.

But in this respect the Australian Observatories, and probably others, are looked upon as silent, isolated, and uninteresting organisations, little understood, and much underrated by the general public.

They are, however, fortunately or unfortunately, called upon to discharge many other functions which bring them into a close relation with the every-day life of their respective colonies. These other non-astronomical functions are principally concerned with local requirements for the service of the community, and absorb no less than two-thirds of their total strength, the other third being stolen by astronomy out of that part of a solar day during which the public is asleep, and leaves the astronomers to do what they please. I believe that in the mind of most people the existence of the Observatories is justified only by those two-thirds of their activity, and this is a danger which cannot be overlooked by those who guard the interests of pure science. Such conditions debar our colonial Observatories from engaging in the more attractive and more speculative parts of astronomical research, and make it necessary that our available astronomical strength should be devoted almost solely to observations and preparation

of data which are more urgently needed, rather than to a more adventurous exploration of the heavens, which, though it might appeal with greater attractiveness to the popular tastes of the age, can be postponed with less detriment to the best interests of astronomical science.

Let us consider the situation.

Sidereal astronomy is well advanced in the Southern Hemisphere. Indeed it was said, ten years ago, that we were ahead of the Northern Hemisphere in point of exact star catalogues, namely, that our skies were richer in accurately-determined positions of landmarks, as Herschel put it, than the northern.

In many other respects, however, our knowledge of the southern heavens is deficient, and there are, indeed, numerous paths which still remain, some partly, some entirely, unexplored. Yet so far as we in Australia are concerned, it seems to me that there can be very little hesitation as to our best course, for the strongest claims to our co-operation are advanced by celestial photography, fundamental transit circle observations, and investigations for the improvement of both these branches of astronomy, which should, therefore, be the objects of our endeavours in the present and immediate future. Indeed these cover a large field; but our share in their general development is well defined, and upon it we may safely devote all our forces with the certainty of doing what is best for the present requirements of astronomy.

It is well known that at a Congress of the leading astronomical authorities in the world, held in Paris in 1887, under the auspices of the French Academy of Science, a great scheme was proposed and decided, by which a permanent record of the appearance of the heavens as could be grasped by the largest modern telescopes would be left as our heritage to the future generations of astronomers.

That the record should be so comprehensive as to give the position of all stars from the brightest to the 11th order of magnitude on Argelander scale with an accuracy as great or greater than that of the best catalogues of our day, and a chart containing all stars down to the 14th magnitude. A project of this nature was made possible only when photography had established its capabilities in the service of astronomy. It would have been beyond the powers of any single institution to accomplish such a task, and the co-operation of Observatories in the Northern and Southern Hemispheres was sought. Eighteen Observatories joined in the undertaking, giving their pledge to execute their proportionate share, submitting faithfully to the rules which would be laid down by the congress for the realisation of a scheme which, in point of breadth, thoroughness, and far-reaching influence, must be recognised as the greatest ever initiated in the history of astronomy.

The Sydney and Melbourne Observatories are among the eighteen institutions participating in the work.

It is with a feeling of deep admiration that I think of the year 1887, when the directors of these two Australian Observatories, with a truly scientific spirit, well knowing the difficulties to be faced, secured the opportunity of rendering a great service to science, and of raising the astronomical prestige of their institutions to the honour and credit of the colonies by inducing their Governments to permit and support their adherence to the purposes of the Astrophotographic Congress, to associate with so many distinguished workers in a common enterprise, which will certainly leave its conspicuous mark among the many extraordinary achievements of our time. You will observe that the work consists of two distinct parts, namely, a catalogue and a chart. Each of these parts involves (for reasons to be given later) the photographing of the whole extent of the celestial sphere twice over; one series of negatives (catalogues) being obtained with short exposures of a few minutes, about five minutes on an average, while the exposure for the other series (chart) extends from forty to ninety minutes.

For the purpose of allotting an approximate equal area to each participating Observatory, the heavens were divided into eighteen zones, bounded by parallels of declination, each zone being taken complete charge of by each Observatory. Thus, Greenwich and Melbourne have charge respectively of the North and South Polar caps; Sydney has the zone adjoining that of Melbourne, and the Helsingfors zone adjoins that of Greenwich.

The intermediate zones are taken up by four other Observatories in the Southern Hemisphere and eleven others in the North.

The complete list is as follows, in order of latitude:—Greenwich, Rome, Catania, Helsingfors, Potsdam, Oxford, Paris, Bordeaux, Toulouse, Alger, San Fernando, Tacubaia, Santiago, La Plata Rio, Cape of Good Hope, Sydney, and Melbourne. The Australian contribution alone is a little more than one-tenth of the total.

The labours of the past years, and the progress made, place it beyond reasonable doubt that the accomplishment of the undertaking is within reach. It may, perhaps, be interesting to some among you to know the principal features of the work, and the first conditions laid out by the International Committee, which I will attempt to describe very briefly, as follows:—All the instruments employed in these operations are of the same class and optical dimensions, and each consists of a double telescope, equatorially mounted, and forming a rigid system, one for photographing, provided with an objective of 13·0 inches aparture, and the other for visual observations, with an objective of 10·1 inches, both of the same focal length—approximately, 134 inches.

The latter telescope is necessary in order to ascertain that the region under exposure is accurately followed.

The photographic plates are 158 mm. square, and cover an area of more than 6 degrees, of which 4 degrees only are used.

In order to define the centre and the orientation of the plate in respect to the region photographed, a latent image of a reticule is impressed on the plate before exposure.

This consists of a set of parallel lines at intervals of 5 millimeters, crossed at right angles by another similar set of lines. On developing the plate after exposure to the sky, an image of the reticule is thus permanently secured.

The intersection of the central lines is taken as the centre of the plate, or of the region photographed; one of the central lines represents the path of an equatorial star, and the other central line at right angles to it consequently corresponds to a celestial meridian. 11,027 plates are required to cover the whole sky once, and the sky is accordingly subdivided for this purpose into as many elementary areas, which are photographed one by one.

The plan decided by a Special Commission of the Permanent Committee for carrying out these operations was as follows:—Imagine parallels of declination to be traced on the celestial sphere, 1 degree apart, from zero at the Equator, to 90 degrees at the Poles. Then on and along the parallels of even degrees, mark equidistant points at intervals of 2 degrees of a great circle.

These points correspond to the centres of the elementary areas which, in the photographs, are represented by the intersection of the central lines of the reseau.

The 11,027 pictures thus obtained would comprise the whole extent of the heavens. As we have seen above, it was prescribed that the entire surface should be photographed a second time, both for the short exposure and long exposure plates.

In the second series, instead of photographing the same elementary areas as in the first, the centres were marked on and along the parallels of odd degrees of declination at intervals of 2 degrees of a great circle, so arranged as to be coincident with the point of junction of four adjoining plates of the first series.

Thus the stars which form their image near the corners of one plate will also appear near the centre of another plate, which is one of the many advantages of the method.

An area of 4 square degrees covers a square of 120 mm. on the plates; but the outer lines of the reseau enclose a square of 130 mm.; the photographs do, therefore, overlap to the extent of 5 mm. on each side.

The plan of distribution and arrangement of the centres of the elementary regions is the same in both the catalogue, or short exposure plates, and the chart, or long exposure plates, each

complete series consisting of 22,054 separate and independent photographs.

It would be hardly appropriate to enter here into further technicalities and details. Suffice it to say that, so far as securing the negatives with the required precision and efficiency, all the difficulties have been gradually conquered, and the work has proceeded satisfactorily for some years past.

One series, namely, that with short exposures, for the star catalogue, has been accomplished by the majority of the co-operating Observatories. Both Sydney and Melbourne terminated their share some time since.

In regard to the second series, with long exposures for the chart proper, a few Observatories are fast approaching completion, some are making fair progress, and others (the South America Observatory, for instance) have not yet commenced.

Sydney is well advanced; but in Melbourne we have not been able to go ahead with the desired speed lately, but the conditions have greatly improved more recently, and the work is now proceeding quite satisfactorily.

As we are bound to complete our Australian share of astrophotographic work, let us see what still remains to be done in this respect.

Actual photographic operation for the chart proper will occupy at least four years. In the meantime, the negatives of the catalogue or short exposure series require to be measured and reduced.

The nature of the measurements consists in determining the rectilinear coordinates of each star on each plate, taking the centre of the plates as the origin.

The resolutions of the Conference held in Paris, in 1896, demands that these co-ordinates shall be correctly determined within 0·2″. That is the linear distances of a star from the central lines of the reticule, as measured micrometrically, ought to be correct within 0·003 millimeters, which is equivalent to a little more than $\frac{1}{10000}$th of an inch.

This is the maximum error allowable. Of these distances there will be probably half a million to measure for the Australian portion.

The measures are then to be subjected to various corrections, and prepared for publication as early as possible. The labour involved in these operations exceeds by far that required for the whole actual photographing, and will take perhaps seven or eight years to accomplish, provided a special bureau is created for the purpose with half a dozen or more assistants.

This is not all. In order that the precise positions which the stars actually occupy in the heavens may be deduced from the position of their photographic images on the plates, it is necessary

to refer these images to the images of a number of stars within the same respective regions which shall have been fundamentally observed with our meridian circles, so that these may be used as zero points not affected by the uncertainty of proper motion.

The Conference decided in 1896 that there should be ten such zero points in each plate if possible.

We have, therefore, for the completion of the Australian part of the photographic catalogue, to form a catalogue of some 12,000 or 13,000 stars, fundamentally observed with transit circles, and reduced to the epoch 1900.

Owing to the great magnitude of these labours, the fear has been felt in some quarters that the refinement sought for the photographic catalogue is beyond our resources, and may indefinitely retard the termination of the work. This apprehension is not a fanciful one, and, as it arises from the practical view taken of existing circumstances, it is likely to produce discouragement. It may be that the intentions of the late Admiral Mouchez, the originator of the astrophotographic scheme, and the ideas entertained by the earlier Conferences, were not so ambitious; but if we look further ahead, and consider from a broad point of view the purposes which the undertaking is intended to serve, there seems to be but one satisfactory conclusion, namely, that delay would be a lesser evil than want of refinement carried even to the utmost degree.

The essential fact to be taken into account is, that this work is, to a very great extent, for the service of the next generation of astronomers, principally to enable them to solve more satisfactorily than we can at present the great problems of sidereal astronomy, which depend on the accuracy of a great number of relatively old observations of star places.

Consequently it seems of paramount importance to attain in the astrophotographic catalogue the highest possible precision, even if it involved an excessive delay.

It must be borne in mind that the probable error of star positions, as deduced from the photographic plates, cannot be of a smaller magnitude than that of positions determined by meridian observations.

The accidental errors which evade analysis leave their element of doubt in observed star places, which will always remain with the photographic positions as well. The systematic errors, though capable of measurement and control to a great extent, are by no means governed by constant and perfectly known laws, and do not receive uniform treatment at the hands of all catalogue makers and computers.

Some uncertainty is therefore involved also in the process of reduction, which will also affect all the photographic positions

That the rectilinear co-ordinates can and will be measured on the plates within the prescribed limit of 0·2″, there can be very little doubt; but if we desire the greatest possible precision in the deduced stars places, our efforts must be directed to secure an equivalent precision in the cases of the stars taken as zero points; and it seems necessary that whatever refinements may be devised and introduced, their adoption should be general and strictly uniform, for the influence of additional means and precautions for eliminating systematic errors from meridian observations and reductions would then be felt beneficially throughout the whole range of fundamental astronomy of position.

It is appropiate to refer here to a proposal of Dr. Gill, made some three years ago, which bears upon this subjeet.

Dr. Gill proposed that an International Congress of Astronomers be held, to answer, among others, the following questions, viz.:—"Are astronomers prepared to enter upon a preliminary study, discussion, and experiment on the practical methods by which the art of observation may be raised to a higher level of accuracy, and its results be derived and published in a more systematic and homogeneous system?"

In recent years it has been sought to improve the determinations of star positions, by investigating certain minute errors which had previously either remained unsuspected, or considered too small for practical treatment. Among these may be classed the latitude variation, and the changes of personal equation in the same observer due to difference of star magnitude, declination, or reversed direction of the apparent motion of the star across the field of view.

On the other hand, it has been questioned whether it would be advisable as yet to introduce the necessary corrections for these errors, owing to the disturbing elements and uncertainties by which their respective investigations may be affected, such, for instance, as the irregular and undetected variation of temperature of parts of the transit circles, the conditions of the observing room, and physiological questions. These matters have been and are being analysed with extreme care by leading authorities in the astronomical world, but the results have not so far been finally accepted for general application.

Further improvements in the reduction of meridian observations have been looked for in another direction, namely, the revision and redetermination of astronomical constants. With a view (among other considerations) of deciding upon the adoption by the National Ephemeries of a uniform system of these constants, a Conference was held in Paris last year for the purpose by the Directors of the National Ephemeries and other prominent astronomers.

The following values were adopted from 1900.

General precession	50·2453
Luni-solar precession	50·3684
m.	40 6711
n.	20·0511
Solar Parallax	8·80
Constant of Nutation	9·21
Constant of Aberration	20·47

The discussion by American astronomers which followed the publication of the above results, especially in regard to the constants of precession and aberration as adopted by the Conference, shows how great is the importance to be attached to the expansion of meridian observations, and how urgent the demands for increased refinement in this class of work. It seems, therefore, that in our immediate future we in Australia also must be deeply concerned in fundamental astronomy of position.

The Adelaide and Perth Observatory could not perhaps have a better opportunity of rendering extremely valuable service, the one by continuing, and the other by joining in due course, in the observation of zero stars for our astrophotographic plates, and to carry on every investigation, according to modern methods, which may tend to improve the observations and free the results from every possible source of error.

Such assistance would be all the more valuable as it would enable the required star places to be determined within a reasonably short interval from the epoch of reduction 1900, and would certainly be in accordance with that system of astronomical co-operation which is rendered so desirable and in fact necessary by the great breadth of modern undertakings, of which the Astronomische Gesellschaft and the astrophotographic scheme are the uppermost exponents of our century.

It may be clearly concluded that the Observatories in Australia need not introduce any more systematic work in their programme for the immediate future than that already considered. Other branches of astronomical research must be left, and recommended to the amateur astronomers of the colonies.

The work of the amateur astronomer lies generally in the direction most suitable to his tastes and means.

If he possess ability and enthusiasm he may indeed be reckoned as a considerable factor in the advancement of his particular sphere of action.

He may take up a subject—a single planet, for instance—and devote all his available time to it, with a very strong probability that he will materially advance our knowledge of that planet.

Many important and interesting paths of research are yet left for exploration in our southern skies. Here, again, co-operation

is to be recommended, although lately this course has not been favourably regarded in some quarters. One of the fears is that by mixing good and bad work the results bear the appearance of mediocrity, and the value of the best work is thus greatly depreciated, if not entirely lost. This is no doubt very true in particular cases, but not to such an extent as to render co-operation such as is practised by the sections of the British Astronomical Association undesirable.

A system which directs the forces of many enthusiastic workers along distinct and controlled channels, all leading to the same end, must be beneficial to the majority of persons concerned, and could hardly fail to utilise energy with a maximum of efficiency.

The inferior amateur soon abandons a course in which he can make no advance. What is mostly to be feared is absence of definite purpose, and the surest remedy against this danger is co-operation and co-ordination.

The best service that can be rendered to astronomy by the amateurs in these colonies is to direct their efforts to a class or classes of observations which cannot be made by observers in the Northern Hemisphere.

Thus the systematic exploration of the more southern skies in search of new objects; accurate and extensive observations in meteoric phenomena are very desirable.

If the stellar magnitude of all the lucid stars south of declination—30° ccould be determined with Pritchard Wedge Photometer—we would have a uniform system of magnitudes complementary to the Uranometria Nova Oxoniensis extending over the whole of the heavens, which would be of the greatest value as an independent series for comparison with the series determined with the meridian Photometers of Prof. Pickering. There are several telescopes in the colonies belonging to private institutions or persons which could be successfully employed in the accomplishment of this task, by judiciously distributing and co-ordinating the work.

These are mere suggestions of courses which seem most desirable to follow.

It would be premature and inappropriate to go further into these questions at present. The possibilities of the future in regard to these and many other astronomical researches depending on private institutions and amateurs can only be gauged by an accurate knowledge of instrumental equipment, and the numerical strength, quality, and zeal of the observers available. Such information is not as yet completely obtainable.

The New South Wales branch of the British Astronomical Association has led a good example, which has been followed by Victoria, and may influence the other colonies to gather together their amateur astronomers.

There is consequently some reason to hope that amateur activity may in the immediate future render valuable services in some of these classes of astronomical observations in which the Government Observatories are unable to take an active part.

Enough has been said, I think, to show in what direction these colonies may co-operate in the best interests of astronomy in proportion to their resources and circumstances.

I will now invite your attention to certain subjects of Terrestrial Physics, which derive their great importance, not only from purely scientific considerations, but from their more or less direct bearing upon our material interests, and also, from the fact that in very recent years, and at the present time, they have been taken up with renewed vigour and determination in the hope of improving our knowledge on many points which still remain unexplained.

Prominent among these subjects is Terrestrial Magnetism.

Nearly 300 years ago, Gilbert advanced his great theory "Magnus Magnes ipse est Globus Terrestris," to account for the observed phenomena of the freely suspended magnetised needle.

To this day science has not been able to determine absolutely whether this theory can be finally accepted as true.

Another theory is that which regards the earth's magnetic field as an induced one, ascribed to the action of electric currents circulating within the earth's crust.

But whether the earth acts as a great magnet, or as a great electro-magnet, science is as yet unable to tell. As Dr. Bauer puts it, no satisfactory answer has as yet been given to the question "Is the earth's magnetism permanent, or induced?"

Still more remote seems to be the probability of discovering the origin of the earth's magnetism, and the cause of its variations and perturbations. Magnetic phenomena, as they occur on the earth's surface, appear to be related to solar activity, atmospheric electricity, and possibly to other meteorological conditions, but the nature of these relations is not known.

These are large theoretical problems awaiting solution in the immediate future.

It has been urged that more systematic and careful observations of earth's currents should be made, as a part of the regular work of magnetic observatories, and that magnetic exploration of the atmospheric layers, and of the bottom of the sea, is as necessary as the exploration of the earth's surface for the solution of these questions.

Of more practical importance, however, is the knowledge of the distribution of the earth's magnetism, and of the laws which govern its variations; for it is this knowledge that enables magneticians to construct those magnetic charts which are of so great a service to navigation and to land surveying, especially in new countries.

And it is, moreover, from the steady increase of this knowledge that we may hope to gain ground towards the solution of some of the riddles mentioned above.

It is, in fact, recognised that the main purpose to which future efforts should be directed is to expand and co-ordinate magnetic work, the world over, for obtaining a more correct and complete knowledge of the distribution of terrestrial magnetism and of its variation. Observe that we require to investigate certain physical conditions of our planet in their total effect—that is, regarding the earth as a whole ; and this object can only be accomplished by a complete magnetic service, carried on under uniform methods for a continued period, forming a great net of magnetic observatories well distributed all over the terrestrial sphere.

But the realisation of these ideal conditions is, at least partly, prevented by insuperable difficulties.

The seas, the deserts, and all inaccessible parts of the earth would always cause large gaps in the plan of magnetic evidence.

The available opportunities, however, are by no means taken full advantage of. The permanent magnetic observatories of the world are, all but three, located in the Northern Hemisphere, and by far the greater part of these are clustered in Europe. The southernmost magnetic station is that at Melbourne, and the great expanse between us and the Antarctic Pole gives no evidence of its present magnetic conditions. Yet the possibilities of making satisfactory progress rest with us.

Dr. Adolf Schmidt has investigated the question of the best possible distribution of magnetic observatories, the combined efforts of which should be brought to bear fully on the magnetic problems of uppermost importance. He has shown that the addition of very few permanent magnetic observatories would very greatly improve the present conditions. Among the localities where such additional magnetic observatories could render a signal service to magnetic science, Australia and New Zealand are specially pointed out. The great importance of a permanent magnetic observatory in New Zealand has long been recognised by leading magneticians, on account of its geographical position.

The establishment of such an observatory in the immediate future seems to be a duty which New Zealand owes to the scientific world, as it would be hardly justifiable for any country to deny such a great service to science.

Indeed, the indifference of the colonies in terrestrial magnetism has been publicly pointed out at Home, and has called forth a well-merited reproach from scientific authorities.

The Melbourne Observatory occupies in this respect a very humiliating position, for although a continuous record of the values and variations of the magnetic elements has been most carefully and industriously kept up for the last thirty years, no

results have as yet been deduced, and we are thus culpable of holding back a great mass of valuable evidence which would undoubtedly throw additional light on almost every problem of terrestrial magnetism.

Hitherto we have dealt with terrestrial magnetism in its general aspect or "in its totality."

There remains the local aspect to be considered, namely, that in which the magnetic operations are principally intended to determine the magnetic conditions of a limited region in minute detail, and constituting what are generally called "magnetic surveys."

Every magnetic survey of a country is not only of special service to that country in regard to the requirements of the land surveyor, the mining engineer, and the geologist, but forms a distinct and much-valued contribution to magnetic science. In these undertakings the field-work is carried on by one or a number of observers, who move from place to place with their portable instruments, observing at selected stations the three magnetic elements, namely, declination, horizontal intensity, and dip, also noting and investigating disturbances in their relation to geological features.

The selection and number of stations in a magnetic survey depend upon the nature of the country and on the more or less elaborate character which the survey is intended to possess.

It may be remarked that the more numerous the stations the more complete will be the survey, provided their distribution be judicious; indeed, there can be very little fear of erring in the direction of making a magnetic survey too minute in detail.

From the field observations results are deduced to represent the value of the magnetic elements for a common epoch, which is called the epoch of the survey. For this purpose it is necessary to know the variations and perturbations of the magnetic elements on the days of observation; and this necessary information is supplied by the permanent magnetic observatory, which is taken as the base station of the survey, and where the registration of these variations is obtained photographically or by frequent observations throughout the twenty-four hours of the day. It is very desirable that the base station should not be too far removed from the locality of the survey.

The next step is to plot on the map the isogonic, isoclinic, and isodynamic lines, or lines of equal declination, inclination, and force respectively.

After the lapse of time the direction of these lines becomes affected by the secular variation, and the magnetic map requires rectification; but the secular variation can only be determined by a new magnetic survey of the same regions after an interval of several years.

This necessity is amply illustrated by the magnetic survey of the British Isles. The first of these surveys was executed in the years 1834–38, the second in 1857–62, and the last in the years 1884–88, and reduced to the epoch 1886.

It may be appropriate to mention that two of these surveys were recommended by the British Association for the Advancement of Science.

Turning now to the Australasian colonies, we find a most excellent magnetic survey of the colony of Victoria made by Dr. Neumayer in the years 1858–1864. No other part of Australasia, however, has been magnetically surveyed.

A new survey of the colony of Victoria is of the greatest importance, as it would settle the question of the secular variation; and with the greater facilities of the present, some deficiencies which were inevitable in the first survey, owing to the conditions of the colony forty years ago, could be remedied. A magnetic survey of the whole of Australia, of Tasmania, and New Zealand may at first sight appear to be a task of enormous magnitude, yet it would be well worthy of these colonies to undertake it; and I consider that the present or immediate future offers good opportunities for its initiation, for the following reasons, namely:—

We have at present a large body of geodetic and land surveyors whose services must gradually become less and less required within the special sphere of their calling, owing to the progressive settlement of the country. Among these professional men it would not be difficult to pick, say, half-a-dozen in each Colony possessing the required aptitude for this delicate class of work. The necessary training would be a matter of a few months, the instruments a matter of a few hundreds of pounds for each Government, and the field-work a matter of a few years.

Permanent magnetic observatories, in addition to Melbourne, could be established with all desired security for efficiency at the Sydney, Adelaide, and Perth Observatories, with little extra yearly expense beyond the initial cost of the instruments.

Other permanent magnetic observatories would be required at Brisbane, Port Darwin, Hobart, and at a southern place in New Zealand. The last two would possess an additional importance over the others, owing to the circumstance that Hobart is the site where a valuable series of magnetic records was secured during the years 1841-48 for the Royal Society of London, which would be of immense advantage to deduce the values of secular variation, and New Zealand on account of its being the most southern station of easy access in our hemisphere.

Port Darwin might not necessarily remain in activity after the completion of the survey. Brisbane would always be of great service—1st, as a base station for its vast territories, where the

accurate knowledge of the magnetic meridian must be of a necessity for its surveyors: and second, for the great assistance it would render to the sea-going magneticians in surveying vessels, who require to verify their instruments by connecting their observations with as many permanent stations as can be obtained.

This last attribute of permanent magnetic observatories is applicable to all the stations here contemplated.

These propositions for the expansion of magnetic work in Australasia may appear exorbitant, and out of all proportion with the resources of these colonies; but the science of terrestrial magnetism is now in a phase of remarkable activity in many parts of the world, and we, by keeping out of its course, simply retard and probably impede its progress.

This is therefore another task which will at least claim our earnest attention in the immediate future, and we may rest assured that by so doing we shall receive the approval and the encouragement of all the authorities in this branch of terrestrial physics, whose objects are so interesting, and whose laws are so obscure.

The next subject to which I desire to draw your attention is terrestrial gravitation, a force which, like terrestrial magnetism, is obscure in its origin, but which is capable of exact measurement at any accessible point of the earth's surface, and its distribution can therefore be ascertained.

If the earth were a regular and homogeneous spheroid, with a smooth surface, we might expect that its attractive force would vary uniformly, according to a simple law, from the Poles to the Equator, and would have the same intensity at all places of equal latitude; so that it would be sufficient to determine its value at one single point, in order to deduce its variation at any other.

But the ranges of mountains and deep oceans, the great differences in the geological conditions of the earth's crust, and probably other irregularities in its figure, disturb this simple distribution, and cause variations and perturbations in the force of gravity, which cannot perhaps be represented by any mathematical formula.

Consequently, if we desire to know its accurate value at any given place, we must simply determine it by actual observation.

Hence the necessity of carrying on this class of observations in every part of the world, in order to improve as much as possible our information on a subject which can hardly be considered secondary in importance to any other branch of terrestrial physics.

This importance may perhaps be better understood in its connection with geodesy, and the figure and size of the earth.

It is well known that discrepancies in geodetic determinations of latitudes and longitudes, when compared with corresponding values from astronomical observations, are frequently considerable,

and that these and other uncertainties can be partly traced to local variations of the force of gravity; consequently the study of these variations may not only assist in improving geodetic results, but may also throw light on the geological conditions of the earth's crust to which the variations of gravity are no doubt related.

The figure and size of the earth are by no means settled questions. We may know the length of its major and minor axes within a few hundred feet; but if we consider that upon these data depends the accuracy of our astronomical constants and magnitudes of the solar system, it seems very desirable to exhaust all possible means of research to increase this accuracy.

More extended gravity observations, it is admitted, would be of great service in further testing and probably improving the value of the ellipticity or the flattening of the earth at the Poles, and the method is more promising than others dependent on geodetic arcs, on precession and nutation, and on perturbations of the moon. We have in the colonies splendid facilities to carry on gravity operations along a meridian of some 30° in length, the results of which would form a magnificent Australian contribution towards the determination of the figure of the earth.

Since the days of Bouguer Borda and other celebrated experimenters and investigators, accurate gravity determinations have been made, hitherto generally by pendulum observations, under two distinct methods, namely, the absolute method, which gives the absolute value of the force of gravity at any given place, and the differential method, which gives only its variation from place to place.

The instruments used have varied from the nearest approach to the ideal pendulum, as a heavy symmetrical mass attached to a thin thread, to the convertible, reversible, and invariable pendulums of Bessel and Kater.

It would be hardly appropriate at this late stage to enter fully upon the many and extremely interesting questions which arose from a discussion of the results obtained in various parts of the world, especially England, India, and Russia; and I shall therefore pass on with all possible directness to the present and future aspect of the case.

During the past few years a well-marked renewal of interest in gravity work has taken place in Europe and America, which, I consider, is partly due to the introduction of less ponderous instruments, and improved methods of observation, which afford greater facilities, conveniences, and rapidity in the execution of gravity surveys.

Extensive operations have been carried on especially in Austria, America, and France; pendulums have been swung at the principal sea-ports more usually frequented by warships; and activity is gradually extending.

It is well it is so, for even the latest published results show very clearly that much remains yet to be learnt from gravity surveys, that existing data have not been fully utilised, and that a great deal more of this work is required.

In the Southern Hemisphere very little indeed has been done in regard to gravity research. There are only a few very scattered determinations made by Austrian naval officers; but nothing that I am aware of at any inland places. In Australia, previously to 1893, we had an absolute determination of the value of g made by Neumayer more than thirty years ago; observations made with Kater's invariable pendulums by the American expedition sent out to New Zealand to observe the Transit of Venus in 1882; two independent values for Melbourne and Sydney, determined by Austrian naval officers with the invariable $1/2^s$ pendulums of Colonel Von Sternech; and nothing more.

But we did not remain passive spectators of the interest taken in other parts of the world in gravity investigations.

In 1893 the Royal Society of Victoria created a committee, styled "The Gravity Survey Committee," for the purpose of initiating and subsequently studying and suggesting the best means to execute a gravity survey of Australia.

The first and most important steps were soon taken.

Kater's invariable pendulums were lent to us by the Royal Society of London, with which a connection was made with the base stations at Greenwich and Kew, and thus established a base or zero point at Melbourne and another at Sydney, which will enable us to carry on the survey entirely on the differential method with any other independent instruments.

A set of three half-second pendulums, with all the necessary accessory apparatus, were constructed at the Melbourne Observatory, under Mr. Ellery's supervision, possessing all the latest improvements, and these our Mr. Love took to England in 1894, and made another independent connection of Greenwich and Kew with Melbourne, with satisfactory results.

This is the present state of gravity work in the colonies.

We have a well-determined zero point, and a complete set of first-rate instruments, with which the gravity survey of this continent can be executed with great facility, and within a reasonable number of years.

It is therefore to be hoped that the Gravity Committee will receive every encouragement and support for the accomplishment of a task which will be a credit to the colonies and a benefit to science.

I cannot refrain from mentioning a wonderful piece of mechanism invented by Professor Threlfall some years since, which has been gradually improved by him and by Mr. Pollock, and submitted to all possible tests.

It is called the gravimeter, and is intended to determine the absolute value of the force of gravity.

It seems to have reached, or nearly reached, the state of perfection, and it is quite probable that it may put a very different aspect on the future of gravity work.

Seismology is one more subject of terrestrial physics, which, as it will necessitate more systematic and thorough investigation in Australia in the immediate future, it is in accordance with the plan of this address that I should mention it.

I know that there is already a committee for seismological research, which was created by our Association, and that its activity has been shown by its interesting reports presented at our past meetings, and published in our volumes.

I may, however, be allowed to point out some new matters, with the hope that my remarks on the subject may not be construed as interfering with the functions of this worthy committee.

The seismological committee of the British Association for the advancement of science some time ago addressed a circular to the Australian Observatories, and, I suppose, to other Australasian Institutions, in which we were requested to co-operate with other parts of the world by securing instrumental records of the correct times and phases of earthquakes and tremors, stating also that these records should be obtained with the same class of instruments.

The proposed instruments are intended to give a photographic record of one horizontal component.

Hitherto in the Australian colonies there has been no attempt made to carry on this class of observations in accordance with any concerted method, and with sufficient accuracy and completeness to efficiently serve the purposes of modern research. It is to be regretted that in recent investigations of earthquake periodicity, and in the relation of earthquake frequency with barometric conditions, the Australian contribution of *data* has been regarded as somewhat uncertain or deficient.

These questions, in addition to that of the velocity of propagation, and many others more especially of a geological character, are of the greatest interest, and I have no doubt that our seismological committee will make suggestions in order that the requests of the Home investigators may be complied with. The seismological instruments we possess at present in the Australian colonies are not, I am afraid, sufficiently sensitive. In Melbourne, for instance, the seismograph of the Observatory is not so sensitive as the unifilar and bifilar magnetographs.

Consequently the slight earth tremors, which are probably of more frequent occurrence than we may suspect, evade observation; and these are of no less importance from the scientific point of view than violent shocks.

It seems very desirable that instruments of the form proposed by the Home committee should be placed at the four Australian Observatories—at Brisbane, Port Darwin, Tasmania, and New Zealand, and that the observations and records should be brought under a uniform and controlled system.

I must now conclude.

It has been my endeavour to show in what direction lay the most urgent demands for scientific activity in these colonies concerning some of the subjects within the scope of our section.

Whether we will be able to satisfy these demands in the immediate future, depends, in the majority of cases here contemplated, more on the attitude and support of the Australian Governments than on personal exertions; for which reason the influence of the recommendations of this Section A, and, through it, that of our Association in its total capacity, may be, and, it is hoped, will be a determinant of success.

No. 1.—FOUR THEOREMS IN SPHERICAL HARMONICS.

By C. Coleridge Farr, B.Sc.

(*Read January* 10, 1898.)

No. 2.—SOME EXPRESSIONS FOR THE COMPONENT OF THE MAGNETIC FORCE PERPENDICULAR TO THE AXIS IN THE INTERIOR OF SOLENOIDS.

By C. Coleridge Farr, B.Sc.

(*Read January* 10, 1898.)

[*Abstract.*]

In this paper the author investigates expressions for the radial component of the magnetic force in the interior of a coil, and shows that it can be expressed in terms of the differential coefficients of the zonal harmonics. The discussion embodies six cases. A table of the values of the first derivatives of the first seven harmonics is given to facilitate numerical calculations.

No. 3.—MAGNETIC HYSTERESIS LOSSES IN FEEBLY MAGNETIC AND IN DIAMAGNETIC SUBSTANCES.

By Professor Threlfall, M.A., and Florence Martin.

(*Read January* 10, 1898.)

[*Abstract.*]

The paper describes an attempt made to measure the magnetic losses in diamagnetic substances by suspending them in a rotating magnetic field and measuring the deflection at any given value of H. The apparatus is described and some of the necessary precautions enumerated. The percentage of initial energy absorbed at fields varying from 200 C.G.S. to 800 C.G.S. is given for sulphur, selenium, and paraffin, and is shown to be about the same for sulphur and paraffin (·00004 and ·000064 respectively) and about ten times as great (·0004) for selenium. The presence of iron is shown to have no special effect unless in the metallic state. Any want of homogeneity was found to very largely increase the energy loss. This suggested that the loss depends upon a boundary effect as well as upon the volume, though it is not clear how this can be. That it is so appears, however, to be the case from the fact that the deflection of a ferromagnetic glass bulb is decreased by filling the bulb with a ferromagnetic liquid, and increased by filling it with a diamagnetic liquid. The difficulties encountered in endeavouring to measure the loss in bismuth by this method are commented on.

No. 4—THE TRIGONOMETRICAL SURVEY OF NEW SOUTH WALES, WITH MENTION OF SIMILAR SURVEYS IN THE OTHER AUSTRALIAN COLONIES.

By T. F. Furber, F.R.A.S., L.S.

(*Read, January* 10, 1898).

INTRODUCTORY.

In a return of the operations of the Trigonometrical Survey of this Colony, published a couple of years back, it is mentioned that in view of the accuracy attained in our primary triangulation a more rigorous method of computation, than had been before used in our survey, had been applied in the reduction of the meridian series south from the Lake George Base; also that a review had been made of the data afforded by the triangulation,

as far as it had gone, in determining the dimensions of the spheroid best conforming to the actual surface covered by the survey. This work, together with some added since, seems to be of sufficient importance to warrant reference to it in greater detail than could be given in the return mentioned, and as some interest may attach to a matter which is here, it is believed, treated for the first time as far as this part of the world is concerned, the following remarks have been prepared.

It is regretted that the practice followed in so many other countries where work of this nature is proceeding, is not adhered to by us. As a rule, publication of not only the results of a survey but of the data and details of reduction is made elsewhere, the object being to enable the data to be combined with those afforded by other surveys in order to secure the most reliable results, and also to permit anyone desiring to use the survey at a future time, when possibly the methods of reduction may be much improved, to apply such improved methods to the original data. Of course it will be understood that these remarks as to publication apply more particularly to the primary triangulation, for, although the breaking down of that triangulation for the purposes of governing chain surveys and aiding construction of maps is of the highest importance, and in fact forms the bulk of the work of a survey, yet it possesses little scientific interest. It is hoped that in due course a full report of the primary triangulation, such as is indicated above, may be published; in the meantime such details as may be included within the limits of a short paper will be presented, giving first a short sketch of the progress of the survey, which may be needed to assist in following the subsequent matter and in estimating the value of the steps taken in carrying it out.

It is proposed also to give a brief description of the similar surveys made or in progress in the other colonies. For information regarding these the writer has to thank the Surveyors-General of the several colonies; the description of the Victorian work has, however, been mainly drawn from a paper by Mr. R. L. J. Ellery, C.M.G., F.R.S., published in the proceedings of the Victorian Institute of Surveyors. The intention is to give here only such a sketch of the work done by our neighbours as will enable the general scope and methods to be gathered, though a study of the history of higher surveying in these colonies forms an object lesson which should prove useful in guiding our future steps.

NEW SOUTH WALES—BASE LINES.

The trigonometrical survey of New South Wales had its inception in 1867, when information was first sought with regard to suitable sites for base lines; the measurement of a base line at Lake George being commenced in 1868, under the direction of the

late Mr. G. R. Smalley. The work then done was, however, abandoned in consequence of an abnormal rise in the lake by which the line was covered in parts to a depth of 2 feet 6 inches, and in 1870 a new site, close to the former, was chosen by the Surveyor-General, Mr. P. F. Adams, under whose supervision the base was measured by Mr. A. C. Betts, work being commenced on 31st October of that year. A report of the mode of measurement, with remarks as to the comparisons of the standard bar with the wooden bars actually used on the base, will be found in a return to Parliament, 31st May, 1871. The standard bar is the $O.I._4$, referred to at page 175 of Colonel Clarke's work on the comparison of standards, published in 1866. The difference between the lengths of the base as found from the measurement and re-measurement was ·542 of an inch in the total length of five and a half miles.

The extension of the triangulation from the base was commenced in 1876, in the beginning of which year Mr. W. J. Conder observed the angles at the south end of the base; observations of angles at the other stations shown on the accompanying map (marked A) being made principally by the last named observer and by Mr. J. Brooks at various dates, as the exigencies of the service permitted.

The base line of verification at Richmond, shown on the map, was measured by Mr. Conder in 1879-80, and a description of the measurement, first with the wooden bars with which the length of the Lake George base had been ascertained, and afterwards with steel bars, will be found as an appendix to the annual report of the Department of Lands for 1880. From this the following details have been extracted. The standard bar, which was the same as that used in 1870, is of cast-iron, about 10 feet long, carrying microscopally fine spots near its extremities, and supplied with thermometers to record the thermal state of the metal, mechanical contrivances to prevent sag or distortion of the bar, from unevenness in its supports, and with micrometer microscopes for viewing the spots. The standard was received many years ago from the Board of Ordnance in England, with its length determined at standard temperature of 62° Fahr., and the coefficient of expansion as deduced from observations made with the Imperial standard yard. The straight line joining the terminal points of the base, which are about 7 miles apart, and are very fine dots in small silver discs let into copper plugs in large stones embedded in massive concrete foundations, was measured with three rods or bars so nearly equal in length to the standard that their difference could be determined with the micrometer microscopes with great precision. The rods in use were of two kinds—wood for the first measure, and steel for the re-measurement. They were both used with the same apparatus, which may be

thus briefly described :—Each bar, encased in a box 6 inches by 6 inches, a little less than 10 feet long, so that the ends project slightly, is supported on two camels having three distinct motions —vertical, lateral, and longitudinal. At the leading end of each box there is fixed a microscope of peculiar construction, admirably adapted for the purpose, and possessing peculiar advantages over any similar appliance. (See engraving appended marked B.) Its special feature is that it consists of two distinct object-glasses fitted at the end of a single tube, each glass having a wire in its focus viewed at the same time by an eye-piece common to both object-glasses, so that one of these wires, being brought by suitable screws into exact coincidence with the spot at the front end of the bar to which it is attached, the rear end of the next bar can be brought into coincidence with the other wire; thus, in the process of measuring, the bars are never brought into actual contact, but are separated by the exact distance between the two wires of the microscope, which quantity had been determined with precision by very powerful micrometer microscopes at the Government Observatory. The great advantage of a microscope of this description is that, the lines of sight being parallel, the distance between two points in coincidence with the wires remains the same at whatever distance the points may be from the object-glasses. This contrivance was suggested by Mr. P. F. Adams, in order to prevent errors arising from change of focus in the microscopes formerly used on the Lake George base-line, and it has proved thoroughly satisfactory.

In the actual measurement with the wooden bars, their lengths were uniformly determined before and after each day's work by comparison with the standard, and the mean of these two determinations was used as the length of the bar for the day. The ground having been cleared and roughly levelled, each bar in succession was then levelled, aligned, and brought into position with reference to the proper wire of the microscopes, until the three were laid, after which the first one laid was carried to the front and so on till the end of the day's work, when a point was firmly placed in the ground immediately below the terminal point of the foremost bar, accuracy of position of this point being secured by suitable apparatus. During the whole process the bars were protected from the direct rays of the sun by a succession of seven frames running on wheels and covered with canvas, so as to form one long tent, which was pushed along as the work proceeded.

The measurement with the steel rods was made in almost exactly the same manner, the only difference being that the lengths of these rods were deduced by computation from their recorded temperatures when in use, instead of, as with the wooden bars, assuming that the mean between the morning and evening lengths would be equal to the mean length for the day. The steel

rods, which were three-eighths of an inch thick, were insulated thermally by wrapping in blankets, the whole being covered by a box with glass windows for reading thermometers placed within, and almost in contact with the bar. Under these circumstances, the steel was found to be affected only very slowly by changes in the outside temperature. By systematically arranged comparisons with the standard under as wide a range of temperature as was practicable, the temperature at which the rods were of standard length and the value of the co-efficient of expansion for each were determined. The bars gave most satisfactory results, but as an additional precaution the comparisons with the standard were so arranged as to be made under conditions as nearly as possible those existing during the measurement. During the course of the experiments some interesting information was obtained as to what is technically known as "lag," or the time which elapses after a change has taken place in the temperature of the body under investigation, before the full amount of this change can produce its effect on the thermometer, the converse of the problem usually met.

The following table shows the length of the line and the actual difference between the two measurements :—

Measurement and Re-measurement—Base of Verification, Richmond.

Section.	Measurement with pine bars.	Measurement with steel rods.	Pine—Steel.
	Feet.	Feet.	Feet.
I.	9696·95860	9696·98541	— ·02681
II.	6348·75810	6348·73853	+ ·01957
III.	5317·22788	5317·24112	— ·01324
IV.	5317·07039	5317·06660	+ ·00379
V.	5106·99705	5107·01080	— ·01375
VI.	5202·32449	5202·34920	— ·02471
	36989·33651	36989·39166	— ·05515

Mean length of base-line... ... 36989·36408 feet.
Difference between measurement and re-measurement... ... 0·662 inch.

COMPARISON OF BASES.

The combined errors of measurement of the two bases and of the intervening triangulation, produced an apparent discrepancy of only one and two thirds inches in the length of the Lake George base. The bases were assumed to be correct and an adjustment of the triangles was made in order to eliminate this small, apparent difference.

INSTRUMENTS.

Azimuthal directions have been measured with 18-inch altazimuth instruments made by Troughton and Simms, two of which have been employed. The one generally used is an excellent instrument with a 3-inch object-glass and filar micrometer eye-piece, with eye-piece motion to view any part of the field. A level attachment is provided for the telescope to enable it to be used in observation of latitude by the Talcott method. The horizontal circle is firmly attached to the base of the instrument, the telescope and four equi-distant micrometers, by which the circle is read, revolving upon its centre. Two lamps are used for illumination, and by a system of prisms and reflectors the parts of the horizontal circle immediately under the micrometers or the similar parts of the vertical circle may be read at will. The altazimuth is mounted on a steel cone, in place of the ordinary wooden stand, the base of the cone being usually embedded in cement upon a solid foundation, and the top of the cone furnished with a movable ring, by which the whole instrument may be revolved over the mark constituting the station. These marks are made in metal plugs set where possible in solid rock and otherwise in stone masses buried in the ground, the plug being surmounted by a masonry, concrete, or rubble cairn on which is erected a pile, usually of 4 in. x 4 in. pine, carrying metal vanes of 3 feet or more radius.

With regard to instruments for work of this class reference must be made to the recent report by Dr. Gill on the geodetic survey of South Africa, which contains so much valuable matter that it may be said to, in a manner, mark an epoch in geodesy. In it mention is made of some points which will probably have an important influence on the future methods of conducting the field work of a triangulation, and not least among these is his discussion of the relative values of large and small theodolites. In this connection he states that during the course of the survey it was shown that the accidental errors of pointing or reading were less to be regarded than those caused by lateral refraction. Not only was it found that a change of wind was sometimes followed by marked change in the direction of a distant station, but that a systematic difference, small but appreciable, existed between

directions measured after and before noon, and the general conclusion was come to that steps were to be taken to reduce the effects of refraction by varying the conditions under which the observations were made rather than by seeking precision from extraordinary accuracy of the instruments used. In this view a 10-inch theodolite was substituted by Dr. Gill for the 18-inch instrument previously employed, and throughout the remainder of the work morning and afternoon observations were combined, the very satisfactory result being that with an instrument of less than one-fourth the weight the probable error of an observed angle was reduced from $\pm$ 0·49″ to $\pm$ 0·33″. The question of weight of instruments is so large a factor in the cost of survey, affecting as it does not only the expense of moving from station to station but also the length of time occupied by the work at each station, that anything which will serve to reduce the weight of apparatus appreciably without militating against the accuracy of the results demands fullest attention, and it is with the hope that the subject will receive the general attention it deserves that it is here introduced.

MEASUREMENT OF ANGLES.

The method of measuring angles, followed during the earlier years of the survey of New South Wales, was to observe the direction of one point as a referring mark and then to sight to each station consecutively in order of azimuth, completing the surround by again observing the referring mark; the instrument was then reversed and the same round of stations was observed in this position, similar rounds being taken after moving the graduated circle so that each station was observed upon different parts of the arc in order to eliminate graduation errors. About twenty observations on to each station were deemed sufficient. In the later angle measures, the method has been to reverse the telescope after each round and observe in reverse order of azimuth back to referring mark, twenty such double sets being altogether observed on different parts of the circle.

COMPUTATION OF TRIANGULATION.

Prior to 1890, when the survey was resumed after having been in abeyance some years, the azimuthal directions derived immediately from the observations were tabulated, without adjustment for correction of reading or bisection of referring mark, and Peirce's criterion was applied in order to determine whether any should be rejected; also, in the computation, no adjustment for "figure" conditions was made except in the case of one or two quadrilaterals. In the primary work done since the year named, the practice in

other surveys of similar importance of making local adjustment and permitting no rejections on account of apparent discordance has been followed, and, in the series of triangles south from the Lake George base to the boundary of the Colony, adjustment to meet the geometrical conditions of such figure has been made by the method of least squares. Owing to the need for attending to the current work of the office and to the staff available for such calculations being limited, none of the older work has been recomputed.

ELEMENTS ADOPTED.

Upon the writer taking charge of the computation of the survey some few years back it was found that the following dimensions for the earth had been made use of in the previous calculations, viz. :—

Major semi-axis $= a = 20{,}923{,}134$ feet.

Polar ,, $= c = 20{,}853{,}429$,,

$$e^2 = \frac{a^2 - c^2}{a^2} = \cdot 00665186$$

These appear to have been derived from Captain Clarke's determination of the elements of the figure of the earth which are as follows :—

		feet.	metres.
Major semi-axis of equator (longitude 15° 34′ east)	$= a =$	20,926,350	= 6378294·0
Minor ,, ,, (,, 105° 34′ ,,)	$= b =$	20,919,972	= 6376350·4
Polar semi-axis	$= c =$	20,853,429	= 6356068·1

It would seem that the equatorial diameter in longitude 152° east had been calculated and adopted with the above polar diameter as defining the spheroid of revolution on which to calculate the work. The adoption of spheroidal elements seems advisable for, notwithstanding that his determination, referred to above, indicates the earth to be of an ellipsoidal figure, Col. Clarke in 1880, writes: "It is necessary to guard against the impression that the figure of the equator is thus definitely fixed, for the available data are far too slender to warrant such a conclusion." The assumption has then been made that the earth is a spheroid of revolution with the first given set of elements and the computations made therefrom. The values given for a surface of revolution by Clarke's 1866 determination have been very generally adopted as most nearly representing the data, and have for many years been used on the United States Coast and Geodetic Survey as well as elsewhere. As it may be of interest to compare the

dimensions arrived at by different authorities, the following are tabulated :—

Date.	Authority.	Ellipticity.	Length of Quadrant (metres.)
1819	Walbeck	1 : 302·8	10,000,268
1830	Schmidt	1 : 297·5	10,000,075
1830	Airy	1 : 299·3	10,000,976
1841	Bessel	1 : 299·2	10,000,856
1856	Clarke	1 : 298·1	10,001,515
1863	Pratt	1 : 295·3	10,001,924
1866	Clarke	1 : 295	10,001,888
1868	Fischer	1 : 288·5	10,001,714
1872	Listing	1 : 289	10,000,218
1877	Schott	1 : 305·5	10,002,232
1878	Jordan	1 : 286·5	10,000,681
1880	Clarke	1 : 293·5	10,001,869

For the four principal of these the following further details are added :—

Element.	Bessel, 1841.	Clarke, 1866.	Coast Survey, 1877.	Clarke, 1880.
Equatorial radius, a	6377397·2 M	6378206·4M	6378054·3M	6378248·5M
Polar semi-axis, c ...	6356079 M	6356583·8M	6357175 M	6356514·7M
Compression $\frac{a-c}{a}$...	1 : 299·15	1 : 294·98	1 : 305·48	1 : 293·5
Mean length of a degree.	111120·6M	111132·1M	111135·9	111131·8

For the elements adopted, various functions much used in the calculations have been tabulated; these include, of course, the logarithms of the radius of meridian curvature and of the normal or radius of curvature in a plane at right angles to the meridian, which are respectively represented by

$$R = \frac{a(1-e^2)}{(1-e^2\sin^2\phi)^{\frac{3}{2}}}; \quad N = \frac{a}{(1-e^2\sin^2\phi)^{\frac{1}{2}}}$$

in which a is the equatorial radius, e the eccentricity of the elliptic meridian section, and ϕ is the latitude. Among other functions tabulated was the logarithm of the quantity $\frac{1}{2\,N\,R\sin 1''}$ which was required in the reduction of the spherical excess by the formula, $\epsilon = \frac{ab\sin C}{2\,N\,R\sin 1''}$ in which a and b are sides of a triangle, C is the angle included between them, and N and R are as above. The following more convenient expressions, however,

have been prepared for the computation of these and some few other functions.

$$\left.\begin{array}{l} a = 6974378 \text{ yds.} \\ b = 6951143 \text{ yds.} \end{array}\right\} \begin{array}{l} \log.\ a \text{ (in chains)} = 5.5010828{,}009 \\ \log.\ b \text{ (in chains)} = 5.4996335{,}422 \end{array}$$

$$e^2 = \frac{a^2 - b^2}{a^2} = {\cdot}006{,}651{,}861{,}006\,;\ \log.\ e^2 = \bar{3}{\cdot}8229431{,}658$$

$$1 - e^2 = {\cdot}993{,}348{,}138{,}994\,;\ \log.\ (1 - e^2) = \bar{1}{\cdot}9971014{,}825$$

$$\text{then R} = \overset{\text{Chains}}{316489{\cdot}3} - \underset{[3{\cdot}19981]}{1584{\cdot}2} \cos 2\,\phi + \underset{[0{\cdot}519]}{3{\cdot}3} \cos 4\,\phi$$

$$\text{N} = \text{R}^{\frac{1}{3}} \times \left(\frac{a^2}{1 - e^2}\right)^{\frac{1}{3}} = \text{R}^{\frac{1}{3}} \times [3{\cdot}6683547]$$

$$r_\alpha = \frac{\text{R N}}{\text{R} \sin^2\alpha + \text{N} \cos^2\alpha} = 1 + \frac{e^2}{1 - e^2} \cos^2\phi \cos^2\alpha = \text{N}\,(1 - [3{\cdot}8258417] \cos^2\phi \cos^2\alpha + [5{\cdot}65168] \cos^4\phi \cos^4\alpha - [7{\cdot}477] \cos^6\phi \cos^6\alpha + \text{etc.})$$

$$\phi - \phi^1 = \underset{[2{\cdot}8377851]}{688''{\cdot}312} \sin 2\phi - \underset{[0{\cdot}06012]}{1''{\cdot}48} \sin 4\phi + \underset{[7{\cdot}407]}{{\cdot}003''} \sin 6\phi$$

$$\log.\ \rho = 9{\cdot}999{,}277{,}185 + \underset{[6{\cdot}8602362]}{{\cdot}000{,}724{,}834} \cos 2\,\phi - \underset{[4{\cdot}25864]}{{\cdot}000{,}001{,}814} \cos 4\,\phi + \underset{[1{\cdot}602]}{000{,}000{,}004} \cos 6\,\phi$$

$$\text{Length of merid}^{\text{n}} \text{ arc} = \underset{[5{\cdot}5003590]}{316489{\cdot}3\,l} - \underset{[3{\cdot}19981]}{1584{\cdot}2} \sin l \cos 2\,\phi_0 + \underset{[0{\cdot}519]}{3{\cdot}3} \sin 2\,l \cos 4\,\phi_0$$

$$\text{Length of } 1^\circ \text{ of merid}^{\text{n}} = 5523{\cdot}780 - \underset{[1{\cdot}44167]}{27{\cdot}648} \cos 2\,\phi_0 + \underset{[9{\cdot}062]}{0{\cdot}115} \cos 4\,\phi_0$$

$$\text{Length of radius of parallel} = \underset{[5{\cdot}5014447]}{317281{\cdot}44} \cos\phi - \underset{[2{\cdot}42256]}{264{\cdot}58} \cos 3\,\phi + \underset{[9{\cdot}519]}{0.33} \cos 5\,\phi$$

$$\text{Length of } 1^\circ \text{ of longtitude} = \underset{[3{\cdot}7433221]}{5537{\cdot}606} \cos\phi - \underset{[0{\cdot}66444]}{4{\cdot}618} \cos 3\,\phi + \underset{[7{\cdot}761]}{0{\cdot}006} \cos 5\,\phi$$

$$\text{Log.}\ \frac{1}{2\,\text{N R} \sin 1''} = 4{\cdot}0112320 + \underset{[7{\cdot}4621729]}{{\cdot}0028985} \cos 2\,\phi - \underset{[4{\cdot}3834]}{{\cdot}0000024} \cos 4\,\phi$$

$$\text{A} = [3{\cdot}6782856] \cos\phi - [1{\cdot}2019649] \cos 3\,\phi + [\bar{2}{\cdot}6004197] \cos 5\,\phi$$

a = semi-axis major, b = semi-axis minor, e = eccentricity.
R = radius of curvature of meridian.
N = normal.
r_α = radius of curvature at azimuth α.
ρ = distance from centre to surface.
ϕ = geographical latitude.
ϕ^1 = geocentric latitude.
ϕ_0 = mean of latitudes of terminals of arc.
l = amplitude of meridian arc.
A = area in square miles of figure bounded by meridians and parallels 1° apart.

ACCURACY, AS COMPARED WITH OTHER SURVEYS.

The errors of close of the triangles will be found on the accompanying map (Map A), and comparison of the errors with those met in other surveys shows the work done here to be of a very high degree of precision. The writer had an opportunity in August, 1893, of making a comparison of the relative accuracy of this and other surveys, principally those of Europe. Thanks to valuable information received from Dr. Helmert, President of the International Geodetic Association, it was possible to present this in a very complete form, and though it was published as an appendix to the departmental report of the work of the year named, yet the results may not be without interest in this paper, and it is therefore reproduced in part, some further information being added from a similar comparison made by Dr. Gill and published by him in 1896.

As a means of comparison, the criterion has been adhered to which is now of general use, viz., General Ferrero's "*m*," which may be taken as representing with close approximation the mean error (as deduced from the closing errors of the various triangles of each system) of the angles used in the survey. This quantity is computed by the formula—

$$m = \left(\frac{\Sigma\Delta^2}{3n}\right)^{\frac{1}{2}}$$

in which Δ is the closing error of the triangle and n the number of triangles dealt with.

The following are the values of m:—

	m. $''$
Austro-Hungary, 1849–88, 674 triangles	± 0·931
Bavaria, 1801–54, 337 ,,	± 1·800
Belgium, 1851–73, 219 ,,	± 0·890
Denmark, 1817–24, 20 ,,	± 0·788
,, 1837–47, 43 ,,	± 0·893
,, 1867–70, 16 ,,	± 0·442
France, old meridian series from Dunkirk to Fontainebleau and Bourges, 1792–1827, 105 triangles	± 1·080
France, triangulation of the parallels, 1804–27, 478 triangles	± 1·900
,, ,, connecting England, 1863, 8 ,,	± 0·510
,, new meridian series, 1870–88, 119 triangles	± 0·560
,, Algerian and Tunis, since 1860, 140 ,,	± 0·830
Great Britain, 1792–1852, 476 triangles	± 1·790
India, Dehra Dun, 80 triangles	± 0·780
,, Gurhagarh meridian series, 108 triangles	± 0·930
,, Singi and Kháupisura meridian series, 101 triangles	± 1·215
Italy, 1850–88, 507 triangles	± 0·940
Mecklenberg, 1854–60, 69 triangles	± 1·157
Norway, 1862–88 (nnmber of triangles unknown)	± 0·720
Portugal, 1856–88, 139 triangles	± 1·126
Prussia, land survey of Prussia, 638 triangles	± 0·567
,, East Prussian degree measurement, 29 triangles	± 0·688

	m. ″
Prussia, 1876–88, 80 triangles	± 0·432
,, Rhenish and Hessian series of the Geodetic Institute, 1847–77, 134 triangles	± 0·769
Roumania, 1855–57, and 1875–88, about 250 triangles	± 0·958
Russia, along 52nd parallel, 1827–88, 43 triangles	± 0·870
,, ,, ,, 1827–88, 38 ,,	± 0·950
,, ,, ,, 1827–88, 67 ,,	± 1·150
,, ,, ,, 1827–88, 64 ,,	± 1·290
,, ,, ,, 1827–88, 84 ,,	± 1·000
Saxony, 1867–78, 197 triangles	± 0·350
South Africa, with 10-inch Repsold theodolite, 134 triangles	± 0·495
,, with 18-inch T. & S. ,, 100 ,,	± 0·735
,, Maclear's angles generally, 64 ,,	± 1·140
Spain, 1868–76, 57 triangles of the Lerida group	± 0·610
Sweden, 1823–88, 384 triangles	± 1·470
Switzerland, 1854–68, 40 triangles	± 0·856
United States, Coast Survey, flat country, 198 triangles	± 1·185
,, ,, San Francisco and Salt Lake, 31 triangles*	± 0·375
Wurtemburg, 1878–88, 3 triangles	± 0·720

For New South Wales, as deduced from the 95 primary triangles already observed,

$$m = \pm 0{\cdot}469$$

while that value would be reduced to ± 0·386 by the omission of four triangles, in which the error is abnormally great, and which would be rejected by Pierce's criterion.

The above figures speak for themselves in showing that our work is probably equal to that done in any part of the world.

LOCAL AND "FIGURE" ADJUSTMENTS.

South from the Lake George base the triangulation has been reduced by (1) determination of the most probable directions at each station with reference to the observations at that station only, (2) formation of equations of condition for each geometrical figure involved, using the angles between the directions derived from the previous step, (3) reduction by the method of least squares of the most probable corrections to satisfy the equations of condition, which work forms the most laborious part of the whole operation.

The mode of adjustment will be best followed from the accompanying example.

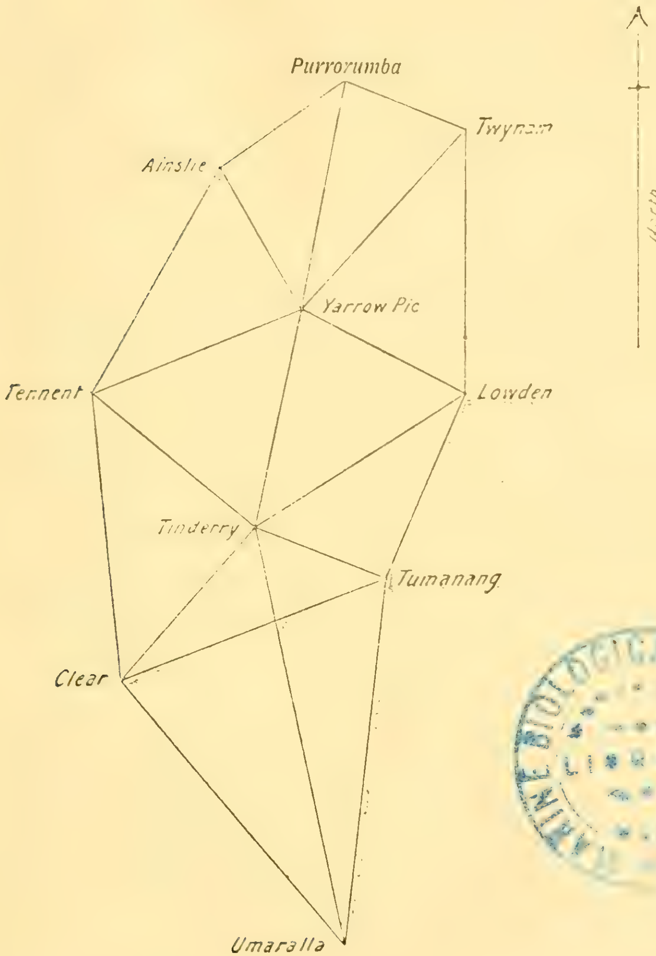
* This result is given, as showing some of the *best* work done in the United States, though it includes the errors of only a small number of triangles. For the whole 229 triangles a value of ± 1·110 is found for m.

Local Adjustment. Station, Kosciusko.

(Observer, J. Brooks; Inst., 18″ T. & S. No. 94; Date of Observation, 20/3/92 to 3/4/92.)

Pilot. 188° 8′	Cabramurra. 21° 42′	Munyang. 55° 0′	Wambrook. 61° 38′	Numbla. 111° 31′	Tingi Ringi. 147° 52′	Tumbarumba 344° 43′	Mueller's Peak 352° 31′	Pilot.	Cabramurra.	Munyang.	Wambrook.	Numbla.	Tingi Ringi.	Tumbarumba	Mueller's Peak	Mean.	Pilot. 188° 8′	Cabramurra. 21° 42′	Munyang. 55° 0′	Wambrook. 61° 38′	Numbla. 111° 31′	Tingi Ringi. 147° 52′	Tumbarumba 344° 43′	Mueller's Peak 352° 31′
30·00	48·05	17·17	46·50	24·40	38·00	..	..	0·00	— ·54	— ·28	+1·25	— ·23	— ·74	..	..	—0·09	30·09	48·14	17·26	46·59	24·49	38·09	..	..
30·00	..	19·60	47·24	24·77	..	..	..	0·00	..	+2·15	+1·99	+ ·14	..	..	..	+1·07	28·93	..	18·53	46·17	23·70	..	..	..
30·00	..	..	47·17	24·22	39·54	..	38·34	0·00	..	..	+1·92	— ·41	+ ·80	..	— ·79	+0·30	29·70	..	..	46·87	23·92	39·24	..	38·04
30·00	46·51	15·67	44·27	22·84	36·94	9·67	..	0·00	—2·08	—1·78	— ·98	—1·79	—1·80	—2·06	..	—1·50	31·50	48·01	17·17	45·77	24·34	38·44	11·17	..
30·00	48·01	..	..	..	40·14	..	..	0·00	— ·58	..	..	..	+1·40	..	..	+0·27	29·73	47·74	..	..	..	39·87	..	..
30·00	46·13	..	46·10	..	..	..	..	0·00	—2·46	..	+ ·85	..	..	..	..	—0·54	30·54	46·67	..	46·64	..	..	..	..
30·00	49·72	17·59	44·89	25·14	41·49	..	..	0·00	+1·13	+ ·14	— ·36	+ ·51	+2·75	..	..	+0·70	29·30	49·02	16·89	44·19	24·44	40·79	..	..
30·00	48·51	15·74	43·08	24·56	39·44	..	..	0·00	— ·08	—1·71	—2·17	— ·07	+ ·70	..	..	—0·56	30·56	49·07	16·30	43·64	25·12	40·00	..	..
30·00	48·71	..	43·71	24·76	38·04	..	..	0·00	+ ·12	..	—1·54	+ ·13	— ·70	..	..	—0·40	30·40	49·11	..	44·11	25·16	38·44	..	..
30·00	48·21	..	43·11	23·66	37·84	..	..	0·00	— ·38	..	—2·14	— ·97	— ·90	..	..	—0·88	30·88	49·09	..	43·99	24·54	38·72	..	..
30·00	..	..	..	..	39·76	..	..	0·00	..	..	..	..	+1·02	..	..	+0·51	29·49	..	..	..	..	39·25	..	..
30·00	..	..	..	..	..	..	38·91	0·00	..	..	..	..	..	..	— ·22	—0·11	30·11	..	..	..	..	..	..	39·02
30·00	..	21·49	..	..	..	..	39·96	0·00	..	+4·04	..	..	..	..	+ ·83	+1·62	28·38	..	19·87	..	..	..	..	38·34
30·00	51·19	19·29	47·54	26·37	..	15·09	..	0·00	+2·60	+1·84	+2·29	+1·74	..	+3·36	..	+1·97	28·03	49·22	17·32	45·57	24·40	..	13·12	..
30·00	49·61	..	47·41	24·48	..	..	..	0·00	+1·02	..	+2·16	— ·15	..	..	..	+0·76	29·24	48·85	..	46·65	23·72	..	..	..
30·00	48·94	..	46·74	25·64	39·76	10·09	..	0·00	+ ·35	..	+1·49	+1·01	+1·02	—1·64	..	+0·37	29·63	48·57	..	46·37	25·27	39·39	9·72	..
30·00	51·61	..	48·74	27·01	39·68	12·08	..	0·00	+3·02	..	+3·49	+2·38	+ ·94	+ ·35	..	+1·70	28·30	49·91	..	47·04	25·31	37·98	10·38	..
30·00	..	..	48·70	..	40·15	..	..	0·00	..	..	+3·45	..	+1·41	..	..	+1·62	28·38	..	..	47·08	..	38·53	..	..
30·00	..	15·52	..	..	..	..	36·42	0·00	..	—1·93	..	..	..	..	—2·71	—1·55	31·55	..	17·07	..	..	..	..	37·97
30·00	46·60	13·25	..	..	..	..	..	0·00	—1·99	—4·20	..	..	..	..	..	—2·06	32·06	48·65	15·31	..	..	..	..	..
30·00	..	..	42·04	24·44	..	..	..	0·00	..	..	—3·21	— ·19	..	..	..	—1·13	31·13	..	..	43·17	25·57	..	..	..
30·00	..	..	44·45	24·85	36·50	..	..	0·00	..	..	— ·80	+ ·22	—2·24	..	..	—0·70	30·70	..	..	45·15	25·55	37·20	..	..
30·00	..	..	42·40	24·40	38·25	..	..	0·00	..	..	—2·85	— ·23	— ·49	..	..	—0·89	30·89	..	..	43·29	25·29	39·14	..	..
30·00	..	..	41·19	25·19	37·67	..	..	0·00	..	..	—4·06	+ ·56	—1·07	..	..	—1·14	31·14	..	..	42·33	26·33	38·81	..	..
30·00	..	..	41·59	20·76	35·61	..	..	0·00	..	..	—3·66	—3·87	—3·13	..	..	2·66	32·66	..	..	44·25	23·42	38·27	..	..
30·00	..	..	44·21	21·61	35·36	..	..	0·00	..	..	—1·04	—3·02	—3·38	..	..	—1·86	31·86	..	..	46·07	23·47	37·22	..	..
30·00	50·04	18·72	47·36	26·56	40·62	..	42·02	0·00	+1·45	+1·27	+2·11	+1·93	+1·88	..	+2·89	+1·65	28·35	48·39	17·07	45·71	24·91	38·97	..	40·37
30·00	50·24	17·87	47·09	26·99	41·21	..	..	0·00	+1·65	+ ·42	+1·84	+2·36	+2·47	..	..	+1·46	28·54	48·78	16·41	45·63	25·53	39·75	..	..
30·00	46·92	..	..	..	..	..	..	0·00	—1·67	..	..	..	..	..	..	—0·84	30·84	47·76	..	..	..	..	..	..
30·00	47·00	..	..	..	..	..	..	0·00	—1·59	..	..	..	..	..	..	—0·80	30·80	47·80	..	..	..	..	..	..
30·00	48·59	17·45	45·25	24·63	38·74	11·73	39·13	..	..	..	..	..	..	..	..	..	30·12	48·52	17·20	45·29	24·72	38·85	11·10	38·75

The figure to be adjusted is that shown on the below diagram which is followed by a table of the locally adjusted bearings at each station, each bearing being followed by the reciprocal of its weight and its symbolical correction.



TWYNAM.

	° ′ ″	$\frac{1}{w}$	
Purrorumba	296 30 18·51	·020	(1)
Lowden	174 31 45·25	·049	(2)
Yarrow	220 27 8·04	·020	(3)

PURRORUMBA.

Twynam	116 31 56·82	·019	(4)
Yarrow	188 7 52·33	·057	(5)
Ainslie	236 34 43·11	·022	(6)

YARROW.

Twynam	40 27 10·17	·014	(7)
Lowden	109 3 35·87	·026	(8)
Tinderry	190 7 33·34	·016	(9)
Tennent	242 44 40·35	·052	(10)
Ainslie	318 41 3·25	·018	(11)
Purrorumba	8 6 14·02	·040	(12)

AINSLIE.

Yarrow	138 42 45·77	·013	(13)
Tennent	198 13 54·24	·023	(14)
Purrorumba	56 34 45·58	·038	(15)

LOWDEN.

Tumanang	200 16 51·93	·039	(16)
Tinderry	232 20 17·43	·057	(17)
Yarrow	289 3 35·11	·050	(18)
Twynam	354 31 48·24	·061	(19)

TENNENT.

Clear	176 57 56·03	·016	(20)
Bimberi	241 55 20·82	·033	(21)
Ainslie	18 12 12·07	·031	(22)
Yarrow	62 44 41·59	·016	(23)
Tinderry	128 25 38·55	·035	(24)

TINDERRY.

Tumanang	107 26 30·92	·013	(25)
Umaralla	167 53 24·68	·018	(26)
Clear	223 10 30·98	·037	(27)
Bimberi	275 19 56·81	·031	(28)
Tennent	308 25 37·44	·029	(29)
Yarrow	10 7 36·02	·049	(30)
Lowden	52 20 22·86	·059	(31)

TUMANANG.

Lowden	20 16 51·96	·022	(32)
Umaralla	187 2 23·81	·077	(33)
Clear	248 49 35·33	·045	(34)
Tinderry	287 26 25·32	·028	(35)

Clear.

	°	′	″	1/[illegible]	
Tennent	356	57	55·47	·046	(36)
Tinderry	43	10	32·64	·024	(37)
Tumanang	68	49	43·39	·048	(38)
Umaralla	139	19	57·09	·040	(39)
Bimberi..	313	53	11·54	·024	(40)

Umaralla.

Clear	319	19	52·49	·031	(41)
Tinderry	347	53	24·88	·055	(42)
Tumanang	7	2	32·27	·026	(43)

From the above, the angle equations are—

$$\text{I.}\quad 0 = +\ {\cdot}825 + (1) - (3) - (4) + (5) + (7) - (12)$$

$$\text{II.}\quad 0 = +\ {\cdot}309 - (5) + (6) - (11) + (12) + (13) - (15)$$

$$\text{III.}\quad 0 = -\ {\cdot}807 - (10) + (11) - (13) + (14) - (22) + (23)$$

$$\text{IV.}\quad 0 = +\ {\cdot}783 - (9) + (10) - (23) + (24) - (29) + (30)$$

$$\text{V.}\quad 0 = -\ {\cdot}133 - (2) + (3) - (7) + (8) - (18) + (19)$$

$$\text{VI.}\quad 0 = +\ {\cdot}162 - (8) + (9) - (17) + (18) - (30) + (31)$$

$$\text{VII.}\quad 0 = -\ 1{\cdot}201 - (16) + (17) + (25) - (31) + (32) - (35)$$

$$\text{VIII.}\quad 0 = -\ {\cdot}379 - (25) + (27) - (34) + (35) - (37) + (38)$$

$$\text{IX.}\quad 0 = -\ {\cdot}701 + (20) - (24) - (27) + (29) - (36) + (37)$$

$$\text{X.}\quad 0 = +\ {\cdot}587 - (33) + (34) - (38) + (39) - (41) + (43)$$

$$\text{XI.}\quad 0 = -\ {\cdot}084 - (26) + (27) - (37) + (39) - (41) + (42)$$

And the side equations are—

$$\text{XII.}\quad 0 = +\ 9{\cdot}241 - 5{\cdot}228(1) - 20{\cdot}387(2) + 25{\cdot}615(3) - 7{\cdot}005(4) + 25{\cdot}667(5) - 18{\cdot}662(6) + 15{\cdot}303(13) - 12{\cdot}394(14) - 2{\cdot}909(15) - 13{\cdot}820(17) + 23{\cdot}428(18) - 9{\cdot}608(19) - 21{\cdot}396(22) + 30{\cdot}911(23) - 9{\cdot}515(24) - 11{\cdot}338(29) + 34{\cdot}548(30) - 23{\cdot}210(31)$$

$$\text{XIII.}\quad 0 = -\ 25{\cdot}009 - 3{\cdot}310(8) + 19{\cdot}397(9) - 16{\cdot}087(10) - 33{\cdot}621(16) + 47{\cdot}441(17) - 13{\cdot}820(18) - 18{\cdot}604(20) - 9{\cdot}515(23) + 28{\cdot}119(24) + 1{\cdot}045(32) - 26{\cdot}363(34) + 25{\cdot}318(35) - 20{\cdot}184(36) + 64{\cdot}023(37) - 43{\cdot}839(38)$$

$$\text{XIV.}\quad 0 = -\ 30{\cdot}601 + 9{\cdot}838(20) - 18{\cdot}991(21) + 9{\cdot}153(24) - 16{\cdot}358(27) + 48{\cdot}662(28) - 32{\cdot}304(29) + 22{\cdot}517(36) - {\cdot}261(37) - 22{\cdot}256(40)$$

$$\text{XV.}\quad 0 = -\ 28{\cdot}426 - 10{\cdot}149(25) - 14{\cdot}588(26) + 24{\cdot}737(27) + 11{\cdot}296(33) - 37{\cdot}659(34) + 26{\cdot}363(35) + 19{\cdot}531(41) - 38{\cdot}683(42) + 19{\cdot}152(43)$$

The corrections in terms of the correlatives and the normal equations are given in the two following tables.

Corrections in terms

	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
(1) =	+ ·020	......	......	......	......	......	......	......
(2) =	......	......	......	......	− ·049	......	......	......
(3) =	− ·020	......	......	......	+ ·020	......	......	......
(4) =	− ·019	......	......	......	......	......	......	......
(5) =	+ ·057	− ·057	......	......	......	......	......	......
(6) =	......	+ ·022	......	......	......	......	......	......
(7) =	+ ·014	......	......	......	− ·014	......	......	......
(8) =	......	......	......	......	+ ·026	− ·026	......	......
(9) =	......	......	......	− ·016	......	+ 016	......	......
(10) =	......	......	− ·052	+ ·052	......	......	......	......
(11) =	......	− ·018	+ ·018	......	......	......	......	......
(12) =	− ·040	+ ·040	......	......	......	......	......	......
(13) =	......	+ ·013	− ·013	......	......	......	......	......
(14) =	......	......	+ ·023	......	......	......	......	......
(15) =	......	− ·038	......	......	......	......	......	......
(16) =	......	......	......	......	......	......	− ·039	......
(17) =	......	......	......	......	......	− ·057	+ ·057	......
(18) =	......	......	......	......	− ·050	+ ·050	......	......
(19) =	......	......	......	......	+ ·061	......	......	......
(20) =	......	......	......	......	......	......	......	......
(21) =	......	......	......	......	......	......	......	......
(22) =	......	......	− ·031	......	......	......	......	......
(23) =	......	......	+ ·016	− ·016	......	......	......	......
(24) =	......	......	......	+ ·035	......	......	......	......
(25) =	......	......	......	......	......	......	+ ·013	− ·013
(26) =	......	......	......	......	......	......	......	......
(27) =	......	......	......	......	......	......	......	+ ·037
(28) =	......	......	......	......	......	......	......	......
(29) =	......	......	......	− ·029	......	......	......	......
(30) =	......	......	......	+ ·049	......	− ·049	......	......
(31) =	......	......	......	......	......	+ ·059	− ·059	......
(32) =	......	......	......	......	......	......	+ ·022	......
(33) =	......	......	......	......	......	......	......	......
(34) =	......	......	......	......	......	......	......	− ·045
(35) =	......	......	......	......	......	......	− ·028	+ ·028
(36) =	......	......	......	......	......	......	......	......
(37) =	......	......	......	......	......	......	......	− ·024
(38) =	......	......	......	......	......	......	......	+ ·048
(39) =	......	......	......	......	......	......	......	......
(40) =	......	......	......	......	......	......	......	......
(41) =	......	......	......	......	......	......	......	......
(42) =	......	......	......	......	......	......	......	......
(43) =	......	......	......	......	......	......	......	......

of the Correlatives :—

I_9	I_{10}	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}
....	....	....	− ·104560	....	....	....
....	....	....	− ·998963	....	....	....
....	....	....	+ ·512300	....	....	....
....	....	....	− ·133095	....	....	....
....	....	....	+1·463019	....	....	....
....	....	....	− ·410564	....	....	....
....	....	....	....	....	....	....
....	....	....	....	− ·086060	....	....
....	....	....	....	+ ·310352	....	....
....	....	....	....	− ·836524	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	+ ·198939	....	....	....
....	....	....	− ·285062	....	....	....
....	....	....	− ·110542	....	....	....
....	....	....	....	−1·311219	....	....
....	....	....	− ·787740	+2·704137	....	....
....	....	....	+1·171400	− ·691000	....	....
....	....	....	− ·586088	....	....	....
+ ·016	....	....	....	− ·297664	+ ·157408	....
....	....	....	....	....	− ·626703	....
....	....	....	− ·663276	....	....	....
....	....	....	+ ·494576	− ·152240	....	....
− ·035	....	....	− ·333025	+ ·984165	+ ·320355	....
....	....	....	....	....	....	− ·131937
....	....	− ·018	....	....	....	− ·262584
− ·037	....	+ ·037	....	....	− ·605246	+ ·915269
....	....	....	....	....	+1·508522	....
+ ·029	....	....	− ·328802	....	− ·936816	....
....	....	....	+1·692852	....	....	....
....	....	....	−1·369390	....	....	....
....	....	....	....	+ ·022990	....	....
....	− ·077	....	....	....	....	+ ·869792
....	+ ·045	....	....	−1·186335	....	−1·694655
....	....	....	....	+ ·708904	....	+ ·738164
− ·046	....	....	....	− ·928464	+1·035782	....
+ ·024	....	− ·024	....	+1·536552	− ·006264	....
....	− ·048	....	....	−2·104272	....	....
....	+ ·040	+ ·040	....	....	....	....
....	....	....	....	....	− ·534144	....
....	− ·031	− ·031	....	....	....	+ ·605461
....	....	+ ·055	....	....	....	−2·127565
....	+ ·026	....	....	....	....	+ ·497952

Normal Equations.

	I_1.	I_2.	I_3.	I_4.	I_5.	I_6.	I_7.	I_8.
I. 0 = + ·825	+ ·170	− ·097	....	....	− ·034	....	....	....
II. 0 = + ·309	− ·097	+ ·188	− ·031	....	....	....	....	....
III. 0 = − ·807	....	− ·031	+ ·153	− ·068	....	....	....	....
IV. 0 = + ·783	....	....	− ·068	+ ·197	....	− ·065	....	....
V. 0 = − ·133	− ·034	....	....	....	+ ·220	− ·076	....	....
VI. 0 = + ·162	....	....	....	− ·065	− ·076	+ ·257	− ·116	....
VII. 0 = − 1·201	....	....	....	....	....	− ·116	+ ·218	− ·041
VIII. 0 = − ·379	....	....	....	....	....	....	− ·041	+ ·195
IX. 0 = − ·701	....	....	....	− ·064	....	....	....	− ·061
X. 0 = + ·587	....	....	....	....	....	....	....	− ·093
XI. 0 = − ·084	....	....	....	....	....	....	....	+ ·061
XII. 0 = + 9·241	+ ·979254	− 1·564102	+ ·673851	+ 1·194053	− ·246225	− 1·103102	+ ·581650	....
XIII. 0 = − 25·009	....	....	+ ·684284	− ·010471	+ ·604940	− 2·998725	+ 3·329442	− 1·745585
XIV. 0 = − 30·601	....	....	....	+ 1·257171	....	....	....	− ·598982
XV. 0 = − 28·426	....	....	....	....	....	....	− ·870101	+ 3·480025

Normal Equations—*continued.*

	I_9.	I_{10}.	I_{11}.	I_{12}.	I_{13}.	I_{14}.	I_{15}.
I. *Continued* ...	....	....	....	+ ·979254	....	....	....
II. ,, ...	....	....	....	− 1·564102	....	....	....
III. ,, ...	....	....	....	+ ·673851	+ ·684284	....	....
IV. ,, ...	− ·064	....	....	+ 1·194053	− ·010471	+ 1·257171	....
V. ,, ...	....	....	.. ..	− ·246225	+ ·604940	....	....
VI. ,, ...	....	....	....	− 1·103102	− 2·998725	....	.. ..
VII. ,, ...	....	....	....	+ ·581650	+ 3·329442	....	− ·870101
VIII. ,, ...	− ·061	− ·093	+ ·061	....	− 1·745585	− ·598982	+ 3·480025
IX. ,, ...	+ ·187	....	− ·061	+ ·004223	+ 1·183187	− 1·536563	− ·915269
X. ,, ...	....	+ ·267	+ ·071	....	+ ·917937	....	− 2·671956
XI. ,, ..	− ·061	+ ·071	+ ·205	.. ..	− 1·536552	− ·598982	− 1·555173
XII. ,, ...	+ ·004223	....	....	+ 257·685071	− 67·630142	+ 7·573442	... .
XIII. ,, ...	+ 1·183187	+ ·917937	− 1·536552	− 67·630142	+ 494·954409	− 15·227620	+ 63·365026
XIV. ,, ...	− 1·536563	....	− ·598982	+ 7·573442	− 15·227620	+ 165·165969	− 14·971970
XV. ,, ..	− ·915269	− 2·671956	− 1·555173	....	+ 63·365026	− 14·971970	+ 224·577647

The deduced values of the correlatives are—

$I_1 = -7{\cdot}2941$	$I_6 = +\ 2{\cdot}9375$	$I_{11} = +6{\cdot}1271$
$I_2 = -5{\cdot}2687$	$I_7 = +\ 8{\cdot}9930$	$I_{12} = -\ {\cdot}0810$
$I_3 = +\ 4{\cdot}9170$	$I_8 = +\ \ {\cdot}9473$	$I_{13} = -\ {\cdot}0337$
$I_4 = +\ \ {\cdot}4582$	$I_9 = +10{\cdot}3610$	$I_{14} = +\ {\cdot}3273$
$I_5 = +\ \ {\cdot}4923$	$I_{10} = -\ \ {\cdot}8545$	$I_{15} = +\ {\cdot}2526$

These substituted in the equations to the corrections, give the following values :—

(1) = − ·1374″	(16) = − ·3065″	(30) = − ·2585″
(2) = + ·0568	(17) = + ·3179	(31) = − ·2464
(3) = + ·1142	(18) = + ·0507	(32) = + ·1970
(4) = + ·1494	(19) = + ·0775	(33) = + ·2855
(5) = − ·2340	(20) = + ·2273	(34) = − ·4691
(6) = − ·0826	(21) = − ·2051	(35) = − ·0628
(7) = − ·1090	(22) = − ·0987	(36) = − ·1063
(8) = − ·0607	(23) = + ·0364	(37) = + ·0250
(9) = + ·0292	(24) = − ·2479	(38) = + ·1574
(10) = − ·2037	(25) = + ·0713	(39) = + ·2109
(11) = + ·1833	(26) = − ·1766	(40) = − ·1748
(12) = + ·0811	(27) = − ·0883	(41) = − ·0105
(13) = − ·1485	(28) = + ·4937	(42) = − ·2003
(14) = + ·1362	(29) = + ·0072	(43) = + ·1036
(15) = + ·2092		

which applied to the bearings give—

TWYNAM.

	°	′	″
Purrorumba	296	30	18·373
Lowden	174	31	45·307
Yarrow	220	27	8·154

PURRORUMBA.

Twynam	116	31	56·969
Yarrow	188	7	52·096
Ainslie	236	34	43·027

YARROW.

Twynam	40	27	10·061
Lowden	109	3	35·809
Tinderry	190	7	33·369
Tennent	242	44	40·146
Ainslie	318	41	3·433
Purrorumba	8	6	14·101

AINSLIE.

	°	′	″
Yarrow	138	42	45·622
Tennent	198	13	54·376
Purrorumba	56	34	45·789

LOWDEN.

Tumanang	200	16	51·624
Tinderry	232	20	17·748
Yarrow	289	3	35·161
Twynam	354	31	48·318

TENNENT.

Clear	176	57	56·257
Bimberi	241	55	20·615
Ainslie	18	12	11·971
Yarrow	62	44	41·626
Tinderry	128	25	38·302

TINDERRY.

Tumanang	107	26	30·991
Umaralla	167	53	24·503
Clear	223	10	30·892
Bimberi	275	19	57·304
Tennent	308	25	37·447
Yarrow	10	7	35·762
Lowden	52	20	22·614

TUMANANG.

Lowden	20	16	52·157
Umaralla	187	2	24·096
Clear	248	49	34·861
Tinderry	287	26	25·257

CLEAR.

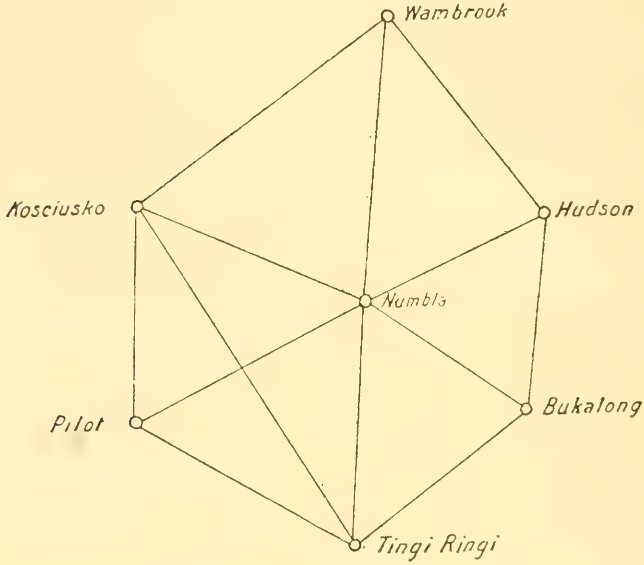
Tennent	356	57	55·364
Tinderry	43	10	32·665
Tumanang	68	49	43·547
Umaralla	139	19	57·301
Bimberi	313	53	11·365

UMARALLA.

Clear	319	19	52·480
Tinderry	347	53	24·680
Tumanang	7	2	32·374

and the triangles are then found to close to within one-thousandth of a second, while the values of the sides are accordant to the ninth place in the logarithms.

The only other figure, any details of the adjustment of which will be given, is that shown in below diagram.



The locally-adjusted directions, &c., are as follows :—

NUMBLA.

	° ′ ″	$\frac{1}{w}$	
Hudson	61 55 52·97	·014	(1)
Bukalong..	119 54 56·11	·048	(2)
Tingi Ringi	188 46 48·64	·021	(3)
Pilot	252 6 45·47	·037	(4)
Kosciusko	291 31 22·25	·025	(5)
Wambrook	13 23 55·02	·041	(6)

WAMBROOK.

Hudson	137 19 9·16	·028	(7)
Numbla..	193 23 54·35	·071	(8)
Kosciusko..	241 38 45·70	·055	(9)

HUDSON.

Bukalong	180 41 58·84	·047	(10)
Numbla..	241 55 49·35	·034	(11)
Wambrook	317 19 10·27	·088	(12)

BUKALONG.

	° ′ ″		
Tingi Ringi	243 17 48·63	·040	(13)
Numbla	299 54 59·59	·087	(14)
Hudson	0 42 9·30	·023	(15)

TINGI RINGI.

Numbla..	8 46 48·01	·017	(16)
Bukalong	63 17 48·26	·074	(17)
Pilot	302 12 48·40	·068	(18)
Kosciusko	327 52 30·44	·050	(19)

KOSCIUSKO.

Pilot	188 8 30·12	·052	(20)
Wambrook	61 38 45·29	·092	(21)
Numbla.............	111 31 24·72	·032	(22)
Tingi Ringi	147 52 38·85	·044	(23)

From the above the angle equations are—

$0 = +{\cdot}209+(1)-(6)-(7)+(8)-(11)+(12)$ I

$0 = -{\cdot}392-(1)+(2)-(10)+(11)-(14)+(15)$ II

$0 = -{\cdot}511-(2)+(3)-(13)+(14)-(16)+(17)$ III

$0 = +{\cdot}274-(3)+(5)+(16)-(19)-(22)+(23)$ IV

$0 = -2{\cdot}238-(5)+(6)-(8)+(9)-(21)+(22)$ V

and the side equations are—

$0=+4{\cdot}993+1{\cdot}416\ (7)-3{\cdot}295\ (8)+1{\cdot}879\ (9)+1{\cdot}156\ (10)-1{\cdot}705\ (11)$
$+0{\cdot}549\ (12)+1{\cdot}387\ (13)-2{\cdot}564\ (14)+1{\cdot}177\ (15)-3{\cdot}931\ (16)+1{\cdot}501\ (17)$
$+2{\cdot}430\ (19)+1{\cdot}775\ (21)-4{\cdot}636\ (22)+2{\cdot}861\ (23)$............... VI

$0=-1{\cdot}827+1{\cdot}058\ (3)-3{\cdot}620\ (4)+2{\cdot}562\ (5)+{\cdot}913\ (16)+3{\cdot}469\ (18)$
$-4{\cdot}382\ (19)+1{\cdot}985\ (20)+{\cdot}501\ (22)-2{\cdot}486\ (23)$ VII

The calculated corrections from these are—

″	″	″
(1) = − ·0287	(9) = + ·3442	(17) = + ·1505
(2) = + ·0451	(10) = − ·2982	(18) = + ·0492
(3) = + ·0378	(11) = + ·1433	(19) = − ·3177
(4) = − ·0279	(12) = + ·1877	(20) = + ·0215
(5) = − ·1438	(13) = − ·2280	(21) = − 1·0023
(6) = + ·2383	(14) = + ·2012	(22) = + ·3928
(7) = − ·1294	(15) = + ·0778	(23) = − ·0788
(8) = − ·1160	(16) = + ·0610	

which applied to the bearings give—

	° ′ ″
Numbla.	
Hudson	61 55 52·941
Bukalong	119 54 56·155
Tingi Ringi	188 46 48·678
Pilot	252 6 45·442
Kosciusko	291 31 22·106
Wambrook	13 23 55·258
Wambrook.	
Hudson	137 19 9·031
Numbla	193 23 54·234
Kosciusko	241 38 46·044
Hudson.	
Bukalong	180 41 58·542
Numbla	241 55 49·493
Wambrook	317 19 10·458
Bukalong.	
Tingi Ringi	243 17 48·402
Numbla	299 54 59·791
Hudson	0 42 9·378
Tingi Ringi.	
Numbla	8 46 48·071
Bukalong	63 17 48·410
Pilot	302 12 48·449
Kosciusko	327 52 30·122
Kosciusko.	
Pilot	188 8 30·142
Wambrook	61 38 44·288
Numbla	111 31 25·113
Tingi Ringi	147 52 38·771

and the triangles are then found to close.

The details of this figure are introduced, as they present a feature of special interest.

The corrections to the figure Hudson, Bukalong, Tingi Ringi, Kosciusko, Wambrook, had been before computed to illustrate a report on the mode of reduction, station Pilot being excluded

from the figure. The following is a comparison of the two systems of corrections :—

Correction.		Excluding Pilot.		Including Pilot.
		″		″
(1)	...	− ·030	...	− ·029
(2)	...	+ ·045	...	+ ·045
(3)	...	+ ·029	...	+ ·039
(5)	...	− ·152	...	− ·144
(6)	...	+ ·240	...	+ ·238
(7)	...	− ·131	...	− ·129
(8)	...	− ·103	...	− ·116
(9)	...	+ ·336	...	+ ·344
(10)	...	− ·302	...	− ·298
(11)	..	+ ·149	...	+ ·143
(12)	...	+ ·182	...	+ ·188
(13)	...	− ·233	...	− ·228
(14)	...	+ ·215	...	+ ·201
(15)	...	+ ·077	...	+ ·078
(16)	...	+ ·065	...	+ ·061
(17)	...	+ ·146	...	+ ·150
(19)	...	− ·290	...	− ·318
(21)	...	− 1·011	...	− 1·002
(22)	...	+ ·391	...	+ ·393
(23)	...	− ·055	...	− ·079

Thus it is shown that in each case, although the conditions are not the same, the same angle is proved by the principle of least squares to be responsible for almost the whole of the abnormal error of close in the triangle Numbla, Wambrook, Kosciusko.

GEODETIC POSITIONS.

For the reduction of the geodetic latitudes and longitudes of the stations, the Sydney Observatory has been adopted as a zero point, its accepted position being latitude 33° 51′ 41·1″ S., longitude 151° 12′ 23·1″ E. Also the azimuth of the triangulation has been referred to the known azimuth of the meridian mark of the same Observatory. The formulæ used in calculating the positions of the stations are—

$$\log\,(\phi_1-\phi)=\log\frac{S\cos\alpha}{\mathrm{R}\sin 1''}+2g$$

$$\phi^1-\phi_1=\ -\frac{S^2\sin{}^2\alpha\tan\phi_1}{2\mathrm{NR}\sin 1''}$$

$$\log\omega\qquad=\log\left(\frac{S\sin\alpha}{\mathrm{N}\cos\phi^1\sin 1''}\right)-f+h$$

$$\log\nu\qquad=\log\left(\omega\sin\frac{\phi^1+\phi}{2}\right)+\frac{3f-g}{4}$$

in which ϕ and ϕ^1 are the latitudes of the points at the extremities of a line the azimuth of which is a; R is the radius of curvature at the middle latitude; N, the normal; S is the length of the line; $f = \frac{MS^2}{6NR}$; $g = f \sin^2 a$; $h = g \sec^2 \phi^1$; and M is the modulus of the common system of logarithms. These formulæ may be taken as precise enough for all distances up to 50 miles. The deduced latitudes and longitudes are as given in the following table which also includes the positions of some few points of a western branch of the triangulation, not elsewhere mentioned in this paper :—

Geodetic Latitudes and Longitudes.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ainslie	35	16	19·132	149	9	35·434
Allen	33	39	50·720	150	45	43·425
Allianoyonyiga	35	2	22·571	149	33	54·960
Bald	33	26	52·417	150	14	26·805
Barren Jack	34	58	0·577	148	36	29·565
Base, L. George, South	35	13	20·472	149	25	31·290
Base, Richmond, North	33	35	58·073	150	46	42·075
Base, Richmond, South	33	39	44·628	150	40	58·485
Bindo	33	40	44·571	150	0	40·485
Blackheath	33	38	38·943	150	17	9·375
Bowning	34	46	47·550	148	49	56·265
Blue Mountain	33	41	56·310	150	27	5·445
Buffalo	34	34	54·814	148	51	47·985
Bukalong	36	48	28·070	149	9	35·882
Burra	34	58	25·731	147	59	58·065
Castle	33	42	26·278	151	0	55·650
Chaton	34	55	45·322	149	17	32·640
Clear	35	52	41·215	149	3	56·990
Conder	33	26	19·047	150	39	1·380
Cooma	36	15	13·396	149	4	47·384
Copperhannia	33	51	57·566	149	14	28·440
Coree	35	18	33·821	148	48	41·790
Cullarin	34	43	33·156	149	23	49·395
Darling	34	6	24·468	148	56	23·700
Euroka	33	52	17·954	150	28	14·745
Flakney	35	17	28·339	147	25	52·440
Fulton	33	46	41·588	149	29	39·240
Gannon	33	57	49·317	151	6	49·110
Geegullalong	34	19	13·269	148	42	25·080
Gibraltar	34	28	2·088	150	25	46·937
Grose	33	37	30·388	150	37	2·985
Howard	33	49	13·904	149	3	20·460

Geodetic Latitudes and Longitudes—*continued.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Hudson's Peak	36	26	35·604	149	10	0·055
Jellore	34	22	16·986	150	22	19·875
Kangaroo	35	4	43·515	148	16	14·835
Kosciusko	36	27	28·350	148	15	53·434
Lambie	33	28	24·043	149	59	24·600
Lowden	35	30	13·010	149	35	0·056
Lowes	33	35	31·313	149	48	45·945
Macalister	34	27	3·499	149	45	16·290
Macquarie	33	38	52·872	149	10	56·790
Maroota	33	28	3·968	150	59	40·200
Minjary	35	13	45·387	148	7	37·080
Mulgoa	33	48	26·329	150	37	57·750
Mundoonen	34	49	47·920	149	2	38·085
Narrawa	34	23	46·627	149	6	48·810
Numbla	36	37	5·743	148	45	18·975
Nundialla	34	29	42·942	150	6	58·440
Observatory	33	51	41·100	151	12	23·100
Ovens	33	24	46·667	149	46	40·590
Pilot	36	45	21·504	148	12	26·348
Potts	33	53	36·834	151	2	5·715
Pound	33	33	7·714	150	41	38·925
Prospect	33	49	10·480	150	55	38·190
Purrorumba	35	9	10·511	149	22	48·780
Red	33	44	31·397	151	3	57·345
Rocks	33	26	31·016	149	24	26·070
Ryan	33	51	0·940	149	27	11·505
Scott	33	32	2·188	150	37	24·540
Shivering	34	7	39·493	150	2	7·590
Spring	35	5	45·054	149	5	7·860
Substitute	37	10	33·405	149	8	10·866
Tennent	35	33	7·039	149	2	46·081
Tinderry	35	41	58·114	149	16	21·449
Tingi Ringi	36	59	59·385	148	40	42·404
Tomah	33	32	45·441	150	25	31·005
Towrang	34	45	21·356	149	49	28·755
Tumanang	35	45	2·244	149	28	18·822
Tumorrama	35	14	28·925	148	30	6·540
Twynam	35	13	20·473	149	32	59·925
Umaralla	36	11	56·006	149	24	13·848
Wambrook	36	11	35·238	148	53	2·408
Warrawolong	33	2	44·885	151	15	59·115
Wells	34	7	31·170	149	13	14·160
Wheel of Fortune	35	3	6·155	147	33	38·415
Willans	35	8	4·834	147	22	24·600
Woronora	34	7	5·980	150	57	14·610
Yarrow	35	25	56·922	149	19	53·086
Yaven	35	13	23·771	147	50	11·190
Yengo	32	59	10·242	150	51	11·970

Having given the co-ordinates x and y of a point A, the distance AB being equal to s, and the angle which AB makes with the meridian of reference being represented by α, the co-ordinates x_1 and y_1 of the point B, and also the back bearing α^1 from B to A, are found by the formulæ—

$$y_1 = y + n - \frac{m^2\ y}{2\ r^2} - \frac{m^2\ n}{6\ r^2}$$

$$x = x + m + \frac{m\ y_1^2}{2\ r^2} - \frac{m\ n^2}{6\ r^2}$$

$$= \pm 180^\circ - \frac{m\ y}{r^2 \sin 1''} - \frac{m\ n}{2r^2 \sin 1''}$$

in which r is the mean radius of the earth at latitude of point midway between A and B (that is, square root of product of radii of curvature of meridian and perpendicular to the meridian), $m = s \sin \alpha$ and $n = s \cos \alpha$.

ALTITUDES OF STATIONS.

The heights of the various stations of the survey are determined from observations of the zenith distances of the surrounding points, made at each station visited by the observing surveyor. The simultaneous observation at each end of the line involved, which is necessary to an ideal determination of relative heights (for by that means only is it made certain that the co-efficients of refraction at the two ends of the line are the same) has, of course, been impracticable. The work, however, is performed always at the same time of the day, so as to secure, as far as possible, the same atmospheric conditions in the reciprocal observations. The actual field work consists in the measurement, with a theodolite having a 10-inch circle, of the elevations of all the stations in the surround, noting, at the time of sighting to each, the reading of a level the axis of which is in the direction of the line being sighted, any variations of the level being subsequently applied to the circle reading. The instrument is then reversed and a similar round taken, each such pair of rounds constituting a set from which the differences of height may be derived. The question may arise whether the number of sets taken has not of recent years been too much limited to give a reasonable assurance that the mean result will represent anything corresponding to a mean condition of the air, and though the resulting heights prove fairly accurate yet improvement may be expected to follow an increase

in the number of observations. There is little doubt that the principal source of difficulty in trigonometrical levelling lies in the considerable and irregular changes in the atmospheric refraction. This cannot be better illustrated than by the experience obtained in India, where apparent zenith distances of points only 10 or 12 miles away varied under certain circumstances through a range of as much as nine minutes. At first sight it might appear to be useless to go on duplicating such apparently wild observations, yet consideration of the nature of the question will show that the great range among the observations forms, itself, the reason for extending them to cover a longer period of time. Bessel's opinion on this subject may be gathered from his estimate of the relative weights* to be assigned to such observations, the principal factor in the weight being $\frac{n_1 \, n_2}{n_1 + n_2}$, where n_1 and n_2 are the number of days on which observations are made at opposite ends of the same line.

The differences of height are computed from the very convenient formula—

$$h_1 - h = s \tan \tfrac{1}{2} (\zeta_1 - \zeta) \left(1 + \frac{h + h_1}{2R} + \frac{s^2}{12 R^2}\right)$$

where h and h_1 are the heights respectively of the initial station and that station the height of which is sought; ζ and ζ_1 are the reciprocal zenith distances observed at each station; s represents the horizontal distance between the stations, and R is the mean radius of curvature of the surface in the vertical plane passing through the two points. This formula involves only one trigonometrical function, and the values of $\frac{h + h_1}{2R}$ and $\frac{s^2}{12R^2}$ are readily obtained from tables prepared with arguments $h + h_1$ and $log\ s$ respectively. Considering the small number of observations referred to above, the deduced heights agree remarkably well both amongst themselves and in comparison with heights obtained by spirit-levelling, principally the levelling made in connection with the railway surveys. The only difference of any magnitude which has been revealed has been near the northern limit of the survey, where the heights of station Skeletar, close to Muswellbrook, deduced trigonometrically and through the spirit-levelling, differ by 9 feet. An adjustment to the railway levels has not in this case been made, as sufficient confidence was not felt in the accuracy of the railway levels. These were made some thirty years back, not under Governmental control, but by a contractor, and the writer is informed that where examined they have not been found

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* Gradmessung in Ostpreussen, p. 196.

trustworthy, errors of several feet having been discovered in places. It is earnestly hoped that it will not be long before spirit-levelling of precision is undertaken in this colony.

The approximate adjustment of errors of close in the altitudes by a system of means, which on taking up the work it was found had been followed, will be shortly replaced by reduction on the principle of making the sums of the squares of the co-efficients of refraction to be a minimum, recognising the refraction as the main disturbing factor.

CO-EFFICIENT OF REFRACTION.

As a preliminary to the determination of the heights of stations along the south coast in the counties of Camden, St. Vincent, and Dampier, the co-efficient of refraction has been calculated from the reciprocal observations on nearly a hundred lines. The mean of all the values obtained is

$$K = 1216 \pm \cdot 0012.$$

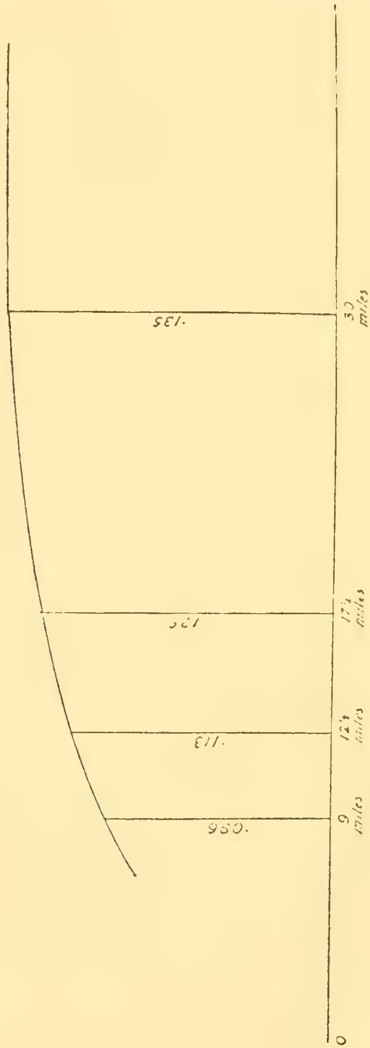
In discussing these determinations the conclusion has been arrived at that the generally accepted formula from which the co-efficient is computed,

$$K = 1 - \frac{R \text{ Sin } 1''}{S} (\zeta + \zeta_1 - 180^\circ)$$

is inadequate, and may without great labour be much improved. In analysing the south coast results it was observed that the lower values were somewhat remarkably associated with the lines of greatest slope and an endeavour was fruitlessly made to connect the two conditions. It however suggested itself that as the steepest lines were usually the shortest, a connection might be found between the change of co-efficient and change of length in the line. The co-efficients were accordingly grouped and gave the following results :—

	Under 10 miles.	10 to 15 miles.	15 to 20 miles.	Over 20 miles.
K =	·096	·113	·126	·135

Plotting these values and taking the average lengths of the lines involved gives the following diagram, which points to the conclusion that the value of the co-efficient may be very closely represented, for distances of less than 30 miles by a circular curve.



Analysis respecting the longer distances shows that, for lines greater than 30 miles, K may be taken as uniformly equal to ·135, and for the results above outlined the co-efficient for shorter distances will be best represented by the following expression, in which D is the distance in miles :—

$$K = \cdot 135 - \cdot 000081\ (30 - D)^2.$$

Examination of some of the results obtained in the United States* shows that they exhibit the same need for bringing the distance in as a function, or what comes to the same thing, the height of the ray above the ground, for it may be assumed to vary with the distance. It would seem then to be established that the practice of using an average value derived from the formula

$$K = 1 - \frac{R \text{ Sin } 1''}{S} (\zeta + \zeta_1 - 180^\circ$$

will need modification. It is to be noted that, in the above discussion, Struves' pressure factor $\frac{B}{29}$, where B represents the mean reading, in English inches, of the barometer at the place of observation, by which all co-efficients may be referred to sea level, has not been applied, the area covered being nearly enough at the one level to enable it to be disregarded without affecting the conclusions. It should be observed too, that the co-efficient determined above results, not the mean refraction, but the refraction at the usual time of observation, 2 to 4 p.m., when though less liable to fluctuation, it is really at one extreme of its daily range.

In the absence of proper topographical surveys which would fix the height of the ray above the surface, it is of some importance to investigate the general effect of changing distance on the refraction. This will be seen when it is remembered that the co-efficient is determinable only by the reciprocal observations which are usually made only on the longer lines of the survey, and that it is, as a rule, needed for application on the shorter lines, which are those fixing stations from which no observations have been made. The great advance which photographic surveying has recently made leads to the hope that it may be usefully applied to obtaining such topographical information as is needed for a proper discussion of terrestrial refraction, both vertical and lateral. In the course of examining the refractions it has been a source of regret that the few photographs from each station, which were needed for this purpose, were not available. The usefulness of even such an approximate topographic survey for affording other information will be referred to later.

* U. S. C. and G. S. Report for 1876, p. 371.

MINOR TRIANGULATIONS.

Before proceeding to the astronomical work of the survey it may be mentioned that to meet various needs, independent triangulations have been made at Sydney, Albury, and Newcastle, which have afterwards been connected with the main triangulation. These were founded upon bases measured with steel tapes, and the comparisons of the lengths, made on connection, shows the reliance which may be placed upon such tape measurements when conducted with only ordinary care. Elsewhere in this paper the main triangulation only is treated of; the large amount of minor work done may be estimated from the accompanying map (marked "C") which illustrates the detail triangulation of one of the counties on the south coast. The whole extent of the survey is shown roughly on map marked "D," the part covered by the primary triangulation being distinguished by cross hatching.

ASTRONOMICAL OBSERVATIONS.

During the progress of the survey, astronomical observations of the latitudes and longitudes of a number of stations have been made, and the azimuth of the work has also been referred to the astronomical azimuth at a number of places. The stations at which these determinations have been made are distinguished by special symbols on map "A." At each station visited the horizontal direction of the magnetic needle is observed, but no measures are made of dip or intensity, the other two elements requisite in investigations of the earth's magnetic force.

LONGITUDE OBSERVATIONS.

The adopted longitude of the initial point of the survey, the Sydney Observatory, is 10h. 4m. 49·54s. east. This is the value deduced from the connection between Australia and Asia effected by Mr. Barrachi and Captain Darwin in 1883 when the difference of longitude, Port Darwin to Singapore, was observed and the connection of Port Darwin with Sydney was made. Since the adoption of this value, other determinations of the longitude arcs on the chain between Singapore and Greenwich have been made, notably that recently completed by Captains Burrard and Lennox-Conyngham, which gives a value for the longitude of Madras differing by —0·308s. (4·62″) from the value, 5h. 20m. 59·42s., used for fixing the Australian longitudes. New measures of this kind, of course, affect the Sydney longitude, and must be taken into account whenever a re-discussion of the subject takes place, but any alteration at present, to accord with these later determinations, is to be deprecated; in fact, considering the many and remote causes of error in longitude observations over long lines, it

is thought that alteration should be deferred until more definite steps, either by improvement of methods or more reliable observation along the whole chain, materially add to the weight of evidence before us.

The accompanying map (marked "E") shows the positions of stations, the longitude of which with respect to the Sydney Observatory has been determined. Some of these have not been connected with by triangulation, and their places were fixed mainly for use in the construction of a map of the colony to take the place of one which has been in use for the last twenty years or more, and in which errors of as much as 8 or 10 miles have been revealed by the trigonometrical survey. The method of observing difference of longitude generally adopted in the United States and other countries has been somewhat varied in this Colony, and now it consists practically in causing the clock at (say) Walgett to record on the chronograph at Sydney, whilst the Sydney clock is recording on the same chronograph, and then the Sydney clock records on the chronograph at Walgett, whilst the clock there is recording its seconds. In this way it is possible to get the difference between the two clocks within a hundredth of a second, and the problem is reduced to obtaining the actual clock errors at the time of comparison, and thus the difference of the time at the two places at the same absolute instant, and herein lies the whole difficulty.

A programme is prepared of stars in groups of three or four, at or near the zenith, and one or two circumpolar stars, one if possible, being *sub-polo*. For this purpose those stars only are used whose right ascensions are well determined. It is necessary that the intervals between the stars should be as short as possible, so as to eliminate unknown variations in the chronometer rate. When possible the level is read, reversed, and read again just before and after each star. The times of transit of the stars over the wires are recorded on the barrel chronograph by the observer pressing the signal-key, every individual second being automatically recorded by the chronometer. The instrument is now rotated through 180 degrees, and another group of stars observed as before; any error in collimation, and also inequality of pivots, is thus eliminated, and a mean of the two corrections deduced from these two groups is the clock correction at or about the middle time of all the observations. This process is repeated with two other groups of stars, and then, if practicable, clock signals are exchanged with Sydney. The observations then proceed in same manner; that is, a group of stars, instrument reversed, another group, instrument reversed, and so on, until, if possible, a second exchange of signals is made, when two or more groups will close the evening's work. A single night's work (says Chauvenet), however, is not to be regarded as conclusive, although

a large number of stars may have been observed and the results appear very concordant ; for, experience shows that there are always errors which are constant, or nearly so, for the same night, and which do not appear to be represented in the corrections computed and applied. Generally, signals were exchanged with Sydney on from three to five nights.

LATITUDE OBSERVATIONS.

The astronomical observations for latitude are made by the method of zenith pairs, the altazimuth being fitted also for use as a zenith telescope ; thus we have combined in the one instrument the means of determining latitude, time, astronomical azimuth, direction and elevation of surrounding points. Results of the observations for latitude at one station, Walgett, are given below.

Latitude—Walgett. Zenith pairs.

Observed by W. J. CONDER.

Date.	Stars.	Observed Latitude.	Mean.	$\sqrt{n}$	Mean $\times$ $\sqrt{n}$	v.	v^2.
1884.		30° 1′ 30″					
18 Oct.	Cape 11,341—11,400	1·71	...	...	...	...	...
19 ,,	,, ,, ,,	1·23	...	...	...	...	...
20 ,,	,, ,, ,,	2·93	...	...	...	...	...
22 ,,	,, ,, ,,	3·11	...	...	...	...	...
23 ,,	,, ,, ,,	1·55	2·11	2·236	4·72	·20	·04
18 ,,	,, 11,428—11,448	1·17	...	...	...	...	...
19 ,,	,, ,, ,,	0·73	...	...	...	...	...
20 ,,	,, ,, ,,	2·90	..	..	..	...	...
21 ,,	,, ,, ,,	0·86	...	...	...	...	...
22 ,,	,, ,, ,,	1·93	...	...	...	...	...
23 ,,	,, ,, ,,	3·10	...	...	...	...	...
24 ,,	,, ,, ,,	2·18	1·84	2·646	4·87	·47	·22
18 ,,	,, 11,476—11,490	1·41	...	...	...	...	...
19 ,,	,, ,, ,,	1·51	...	...	...	...	...
20 ,,	,, ,, ,,	2·97	...	...	...	...	...
21 ,,	,, ,, ,,	1·43	...	...	...	...	...
22 ,,	,, ,, ,,	2·26	...	...	...	...	...
23 ,,	,, ,, ,,	1·64	...	..	...	...	...
24 ,,	,, ,, ,,	1·77	1·86	2·646	4·92	·45	·20
19 ,,	,, 11,476—11,539	2·94	...	...	...	...	...
20 ,,	,, ,, ,,	3·58	...	...	...	...	...
21 ,,	,, ,, ,,	2·54	...	...	...	...	...
22 ,,	,, ,, ,,	2·97	...	...	...	...	...
23 ,,	,, ,, ,,	2·88	...	...	...	...	...
24 ,,	,, ,, ,,	2·35	2·88	2·449	7·05	·57	·32
19 ,,	,, 11,490—11,508	0·25	...	..	...	...	...
20 ,,	,, ,, ,,	2·08	...	...	...	..	
21 ,,	,, ,, ,,	1·07	...	...	...		

Latitude—Walgett. Zenith pairs—*continued.*

Date.	Stars.	Observed Latitude.	Mean.	$\sqrt{n}$	Mean $\times$ $\sqrt{n}$	v.	v^2.
1884.		30° 1′ 30″					
22 Oct.	Cape 11,490—11,508	2·17	...	...	...	..	...
23 ,,	,, ,, ,,	1·20	...	...	...	...	...
24 ,,	,, ,, ,,	2·10	1·48	2·449	3·62	·83	·69
19 ,,	,, 11,508—11,539	1·68	...	...	...	...	...
20 ,,	,, ,, ,,	2·68	...	...	...	...	...
21 ,,	,, ,, ,,	2·18	...	...	...	...	...
22 ,,	,, ,, ,,	2·87	...	...	...	...	...
23 ,,	,, ,, ,,	2·43	...	...	...	...	...
24 ,,	,, ,, ,,	2·68	2·42	2·449	5·93	·11	·01
19 ,,	,, 11,567—11,587	2·56	...	...	...	...	...
20 ,,	,, ,, ,,	3·48	...	...	...	...	...
21 ,,	,, ,, ,,	2·79	...	...	...	...	...
22 ,,	,, ,, ,,	3·23	...	...	...	...	...
23 ,,	,, ,, ,,	2·95	...	...	...	...	...
24 ,,	,, ,, ,,	2·75	2·96	2·449	7·25	·65	·42
19 ,,	,, 11,567—11,610	2·27	...	...	...	...	...
20 ,,	,, ,, ,,	3·38	...	...	...	...	...
21 ,,	,, ,, ,,	2·52	...	...	...	...	...
22 ,,	,, ,, ,,	3·36	...	...	...	...	...
23 ,,	,, ,, ,,	2·45	...	...	...	...	...
24 ,,	,, ,, ,,	3·08	2·84	2·449	6·96	·53	·28
19 ,,	,, 11,633—11,652	0·98	...	...	...	...	...
20 ,,	,, ,, ,,	3·49	...	...	...	...	...
21 ,,	,, ,, ,,	2·82	...	...	...	...	...
22 ,,	,, ,, ,,	3·72	...	...	...	...	...
23 ,,	,, ,, ,,	3·21	...	...	...	...	...
24 ,,	,, ,, ,,	2·64	2·81	2·449	6·88	·50	·25
19 ,,	,, 11,707—11,746	0·79	...	...	...	...	...
20 ,,	,, ,, ,,	2·45	...	...	...	...	...
21 ,,	,, ,, ,,	1·13	...	...	...	...	...
22 ,,	,, ,, ,,	2·00	...	...	...	...	...
23 ,,	,, ,, ,,	1·91	...	...	...	...	...
24 ,,	,, ,, ,,	1·91	1·70	2·449	4·16	·61	·37
19 ,,	,, 11,783—11,799	2·19	...	...	...	...	...
20 ,,	,, ,, ,,	3·08	...	...	...	...	...
21 ,,	,, ,, ,,	2·40	...	...	..	...	...
22 ,,	,, ,, ,,	3·45	...	...	...	...	...
23 ,,	,, ,, ,,	2·90	...	...	...	...	...
24 ,,	,, ,, ,,	3·11	2·86	2·449	7·00	·55	·30
19 ,,	,, 11,833—11,869	2·11	...	...	...	...	...
21 ,,	,, ,, ,,	2·44	...	...	...	...	...
22 ,,	,, ,, ,,	3·07	...	...	...	...	...
23 ,,	,, ,, ,,	3·06	...	...	...	...	...
24 ,,	,, ,, ,,	2·35	2·61	2·236	5·84	·30	·09
19 ,,	,, 11,919—11,961	2·23	...	...	...	...	...

Latitude—Walgett. Zenith pairs—*continued.*

Date.	Stars.	Observed Latitude.	Mean.	$\sqrt{n}$	Mean $\times$ $\sqrt{n}$	v.	v^2.
1884.		30° 1′ 30″					
20 Oct.	Cape 11,919—11,961	2·88	...	...	...	...	...
21 ,,	,, ,, ,,	1·88	...	...	...	...	...
22 ,,	,, ,, ,,	3·17	...	...	...	...	...
23 ,,	,, ,, ,,	2·57	...	...	...	...	...
24 ,,	,, ,, ,,	1·76	2·42	2·449	5·93	·11	·01
18 ,,	,, 11,991—12,016	1·55	...	...	...	...	...
19 ,,	,, ,, ,,	2·14	...	...	...	...	...
21 ,,	,, ,, ,,	1·79	...	...	...	...	...
22 ,,	,, ,, ,,	4·11	...	...	...	...	...
23 ,,	,, ,, ,,	1·40	...	...	...	...	...
24 ,,	,, ,, ,,	1·63	2·10	2·449	5·14	·21	·04
19 ,,	,, 12,054—12,101	2·20	...	...	...	...	...
20 ,,	,, ,, ,,	2·97	...	...	...	...	...
21 ,,	,, ,, ,,	2·56	...	...	...	...	...
22 ,,	,, ,, ,,	1·98	...	...	...	...	...
23 ,,	,, ,, ,,	3·04	...	...	...	...	...
24 ,,	,, ,, ,,	1·94	2·45	2·449	6·00	·14	·02
19 ,,	,, 12,134—12,150	2·03	...	...	...	...	...
20 ,,	,, ,, ,,	2·36	...	...	...	...	...
21 ,,	,, ,, ,,	1·68	...	...	...	...	...
22 ,,	,, ,, ,,	1·43	...	...	...	...	...
23 ,,	,, ,, ,,	3·21	...	...	...	...	...
24 ,,	,, ,, ,,	2·58	2·22	2·449	5·44	·09	·01
19 ,,	,, 12,150—12,197	1·77	...	...	...	...	...
20 ,,	,, ,, ,,	3·47	...	...	...	...	...
21 ,,	,, ,, ,,	2·70	...	...	...	...	...
22 ,,	,, ,, ,,	2·53	...	...	...	...	...
23 ,,	,, ,, ,,	4·41	...	...	...	...	...
24 ,,	,, ,, ,,	3·21	3·02	2·449	7·40	·71	·50
19 ,,	,, 12,230—12,270	1·84	...	...	...	...	...
20 ,,	,, ,, ,,	2·80	...	...	...	...	...
21 ,,	,, ,, ,,	2·09	...	...	...	...	...
22 ,,	,, ,, ,,	1·30	...	...	...	...	...
23 ,,	,, ,, ,,	2·76	...	...	...	...	...
24 ,,	,, ,, ,,	2·57	2·23	2·449	5·46	·08	·01
19 ,,	,, 12,297—12,338	0·46	...	...	...	...	...
20 ,,	,, ,, ,,	2·43	..	...	...	...	...
21 ,,	,, ,, ,,	1·24	...	...	...	...	...
22 ,,	,, ,, ,,	0·46	...	...	...	...	...
23 ,,	,, ,, ,,	1·71	...	...	...	...	...
24 ,,	,, ,, ,,	1·20	1·25	2·449	3·06	1·06	1·12
20 ,,	,, 12,381—12,420	3·26	...	...	...	...	...
21 ,,	,, ,, ,,	3·60	...	...	...	...	...
22 ,,	,, ,, ,,	2·60	...	...	...	...	...
23 ,,	,, ,, ,,	3·49	...	...	...	...	...

Latitude—Walgett. Zenith pairs—*continued.*

Date.	Stars.	Observed Latitude.	Mean.	$\sqrt{n}$	Mean $\times$ $\sqrt{n}$	v.	v^2.
1884.		30° 1′ 30″					
24 Oct.	Cape 12,381—12,420	2·87	3·16	2·236	7·07	·85	·72
20 ,,	,, 63—83	3·43	...	...	...	...	...
21 ,,	,, ,, ,,	1·88	...	..	...	..	...
22 ,,	,, ,, ,,	2·91	...	...	...	...	...
23 ,,	,, ,, ,,	3·70	...	...	...	...	...
24 ,,	,, ,, ,,	2·31	2·85	2·236	6·37	·54	·29
23 ,,	,, 111—164	3·01	...	...	...	...	...
24 ,,	,, ,, ,,	1·33	2·17	1·414	3·07	·14	·02
21 ,,	,, 132—164	2·32	...	...	...	...	...
22 ,,	,, ,, ,,	3·12	...	...	...	...	...
23 ,,	,, ,, ,,	4·05	...	...	...	...	...
24 ,,	,, ,, ,,	2·72	3·05	2·000	6·10	·74	·55
21 ,,	,, 220—268	1·97	...	...	...	...	...
22 ,,	,, ,, ,,	2·66	...	...	...	...	...
23 ,,	,, ,, ,,	3·27	...	...	...	...	..
24 ,,	,, ,, ,,	2·87	2·69	2·000	5·38	·38	·14
21 ,,	,, 268—306	1·36	...	...	...	...	...
22 ,,	,, ,, ,,	1·66	...	...	...	...	...
23 ,,	,, ,, ,,	2·22	...	...	...	...	...
24 ,,	,, ,, ,,	1·58	1·70	2·000	3·40	·61	·37
21 ,,	,, 352—386	0·60	...	...	...	...	...
22 ,,	,, ,, ,,	1·76	...	...	...	...	...
23 ,,	,, ,, ,,	1·85	...	...	...	...	...
24 ,,	,, ,, ,,	0·50	1·18	2·000	2·36	1·13	1·28
22 ,,	,, 352—401	1·34	...	...	...	...	...
23 ,,	,, ,, ,,	1·92	...	...	...	...	...
24 ,,	,, ,, ,,	0·65	1·30	1·732	2·25	1·01	1·02
				62·117	143·63		9·29
					2·31		

Latitude, 30° 1′ 32·31″. P.E. ± 0·08″.

MICROMETER VALUES IN LATITUDE OBSERVATIONS.

From the mode of observing it is to be noted that the accuracy of the latitude results depend, to a large extent, on the value of the micrometer screw, and, recognising this, it was asked some time back that observations might be made to re-determine the value, for verification of the adopted one which rested on measures made as long ago as in 1882. As micrometers are so generally used in astronomical work, as well as in other branches of physical science, and since they are too generally relied on as being

little liable to any appreciable change, it is thought the errors found in this particular screw might with advantage be brought under notice. It is clear that micrometers in frequent use need examination at short intervals.

In the reduction of the value of the revolution of the latitude micrometer screw it was recognised at the outset that there were certain peculiarities which demanded that it should have more detailed examination than is usually needed. The work, though apparently most carefully carried out, evidenced the existence of systematic error, which depended on the part of the screw used.

The results show that systematic corrections need to be made to the micrometer readings. Each observation of time, after the first one of each set, gives an equation of the form $ax+by+n=o$ where x is a correction to the initial observation and y is a small correction to an assumed value of the micrometer revolution. Substituting the resulting values in the observation equations, the residuals in the case of each set of observations exhibit changes of which the following, which are the residuals in the case of star Cape 1880, No. 6,703, observed 1896, February 19, are an example :—

R	V	R	V	R	V	R	V
	"		"		"		"
33	−1·29	26	−0·09	19	+0·83	12	−0·30
32·5	−1·40	25·5	−0·31	18·5	+0·36	11·5	0·00
32	−1·47	25	+0·76	18	+1·57	11	−0·22
31·5	−1·28	24·5	+0·56	17·5	+1·49	10·5	−0·94
31	−1·52	24	+0·47	17	+1·28	10	−0·64
30·5	−0·67	23·5	+1·17	16·5	+1·17	9·5	−0·23
30	+0·17	23	+0·06	16	+1·12	9	−0·93
29·5	−1·09	22·5	+1·40	15·5	+0·52	8·5	−0·75
29	−0·38	22	+0·94	15	+0·06	8	−1·86
28·5	+0·18	21·5	+1·62	14·5	+0·74	7·5	−1·57
28	−0·59	21	+1·67	14	+0·01	7	−1·13
27·5	−0·76	20·5	+0·81	13·5	−0·19	6·5	−1·33
27	−0·45	20	+1·77	13	−0·14	6	−1·16
26·5	−0·41	19·5	+1·69	12·5	+0·80		

The systematic nature of these residuals is plainly visible and is shown throughout the observations, the set given being merely typical of what is revealed by all. So definite a curve is shown by all that it was clear that a system of corrections of the form $\kappa\ (20—\mathrm{R})^2$ could be determined, which would fairly represent the observed facts. Such corrections have been computed, the constant κ being found to be $0''{\cdot}014$. These corrections, required at each micrometer reading, are as follows, the first column giving the reading of the micrometer, the second the correction in arc,

and the third the same correction in terms of R. The corrections for readings from 20 to 35 will be the same as those below, but in reverse order:—

R.	"		R.	"	
5	+ 3·150	+ 0·054	13	+ 0·686	+ 0·012
5·5	2·940	·050	13·5	·588	·010
6	2·744	·047	14	·504	·009
6·5	2·548	·043	14·5	·420	·007
7	2·366	·040	15	·350	·006
7·5	2·184	·037	15·5	·280	·005
8	2·016	·034	16	·224	·004
8·5	1·848	·031	16·5	·168	·003
9	1·694	·029	17	·126	·002
9·5	1·540	·026	17·5	·084	·001
10	1·400	·024	18	·056	·001
10·5	1·260	·021	18·5	·028	·000
11	1·134	·019	19	·014	·000
11·5	1·008	·017	19·5	·004	·000
12	0·896	·015	20	·000	·000
12·5	0·784	·013			

It will be unnecessary to draw attention to the magnitude of these corrections; they are sufficiently startling. They are, however, fully borne out by the observations. For instance, to return to the case of star 6703 for an example, the observations of this star show that ten (10) revolutions of the screw in its different parts represent the following angular intervals:

	10 R. "		10 R. "		10 R. "
34 – 24	588·62	27·5 – 17·5	589·53	21·5 – 11·5	585·66
33 – 23	588·63	27 – 17	589·01	21 – 11	585·39
32·5 – 22·5	591·08	26·5 – 16·5	588·36	20·5 – 10·5	585·52
32 – 22	589·68	26 – 16	588·49	20 – 10	584·87
31·5 – 21·5	590·18	25·5 – 15·5	588·08	19·5 – 9·5	585·36
31 – 21	590·57	25 – 15	586·58	19 – 9	585·52
30·5 – 20·5	588·76	24·5 – 14·5	587·46	18·5 – 8·5	586·17
30 – 20	588·88	24 – 14	586·82	18 – 8	583·85
29·5 – 19·5	590·05	23·5 – 13·5	585·92	17·5 – 7·5	584·22
29 – 19	588·49	23 – 13	587·07	17 – 7	584·87
28·5 – 18·5	587·46	22·5 – 12·5	586·68	16·5 – 6·5	585·27
28 – 18	589·53	22 – 12	586·04	16 – 6	585·00

The meaning of the above is that the result of measurement of an angle by ten revolutions of the screw at *one* part of its length differs by as much as 5 seconds from the result when *another* part of the screw is used.

The effect of this error of screw on the observations ordinarily made with this micrometer (zenith distance observations for latitude) will of course not be so considerable as that just referred to, as it is usual to set the telescope as nearly as possible at the mean zenith distance of each pair of stars, so that the observations are made pretty symmetrically with regard to the middle reading (20 R) of the screw. This cannot always be done though, and in

fact seldom is done exactly, and whenever the readings are *not* equally distant, on opposite sides of 20 R, a correction is necessary. In one case, an exceptional one certainly, it was found that the difference of zenith distance required correction on this account by as much as $1\frac{1}{2}''$. Although the effect of such errors would be reduced by combination of many pairs of stars, as it would be improbable that the error of screw would have the same sign with each pair of stars; still it is shown clearly enough that this is a source of error to be reckoned with, and it is one which will most likely increase.

As to its cause there can be little doubt. Seeing the thousands of measures made with the screw since 1882, when it was last examined, the wonder would be if by now the effects of wear were *not* to be seen, and it is probable that wear *is* the cause of the different values given by different parts. If, as in the present case, a screw is more frequently used in one part than in another, and one side only of its thread is subject to friction owing to the constant action of a spring, it seems patent that the consequent wear must ultimately result in an appreciable alteration of the position of the thread at the more used part relative to the thread at the less used parts; the interval on one side of the used part being increased in length, and that on the other side decreased. Such action would entirely account for the defect observed in this screw. The middle of the screw is most used; and the interval from the middle to one end is found to have increased beyond the value it had in 1882, while the other end has correspondingly decreased.

TEMPERATURE EFFECT ON MICROMETER.

The values of the micrometer revolution, as derived from the various stars, are as follows:—

From star	72, R=58″·629	From star	8914, R=58″·672
,,	6703, R=58″·728	,,	9273, R=58″·806
,,	1630, R=58″·634	,,	2452, R=58″·552

The mean is R = 58″·670. It is noted that though the theoretical probable errors of these values, arrived at from each individual set, are only ± ·″007, ± ·″006, ± ·″003, ± ·″001, ± ·″002, and ± ·″003, respectively, yet much larger differences are found between the above determinations. This points to a divergence of the conditions under which the observations were made, and it is to be regretted that in such observations the temperature of the instrument is not generally noted, in order that it might be ascertained whether *that* is a disturbing element. In delicate work of this kind some means should be found for ascertaining the temperature of the instrument, as it must change not only from the observer's presence but from the effect of the actual

applications of his hand to the instrument. The one temperature recorded was 35° ; and if this was the air temperature, it is very certain that that of the telescope was much higher, after being touched as many as fifty times during the 20 minutes occupied by the work.

In connection with the remarks on temperature, it is a somewhat significant fact that the values given in the preceding paragraph seem to bear a direct relationship to the time occupied over the observations, the lowest value being given by the set which was the most rapidly made, and the highest by that which took the longest time. Arranged in order of time occupied, they are—

Star 2452	...	R=58″·552	Star 8914	...	R=58″·672
„ 1630	...	R=58″·634	„ 6703	...	R=58″·728
„ 72	...	R=58″·629	„ 9273	...	R=58″·806

So uniform are the progressions in time and value that it is difficult to resist the conclusion that there is a connection between them, and this is probably through the changes of temperature caused by the proximity and touch of the observer.

DECLINATIONS OF STARS.

The effect of errors in the adopted declinations of the stars observed is clearly seen in the latitude results, and wherever more reliable declinations have been applied they have been much improved. In connection with this it is apparent that a great work remains to be done, in combining the positions given in the various star catalogues ; and attention may be drawn to the reduction, by Dr. H. S. Davis, of the declinations and proper motions of stars required for the observation of variation of latitude at New York.* Dr. Davis has brought together for some fifty-six stars the work given in 130 catalogues, and so has obtained declinations of enormously greater weight than could be assigned to those given by any one observatory. For instance, in the determination of μ *Geminorum*, the data afforded by no less than 1,748 observations has been availed of, yet in the previously published catalogues the largest number brought together in a form available for general use was 179. Though the observatories all over the world have been at work gathering information for many years, it yet remains to have the results combined. Rigorous reductions of this kind no doubt involve a large amount of labour, and it can hardly be proposed to at once enter on such a reduction of *all* the star places. A first step, though, might be made by subdividing the heavens into areas of, say, 5 degrees by 5 degrees, selecting the star in each subdivision which has been best

* See Contributions from the Observatory of Columbia College, New York. No. 8. J. K. Rees, Director. Similar work has also been done by Dr. Auwers.

determined in position (that is, observed at the largest number of different observatories, not the one all the observations of which, though numerous, may have all been made at only a few places), reducing its place and proper motion rigorously, and determining, by differences, the places of the principal other stars in the same subdivision, using the selected star as a point of reference. In this way the best information would be obtained for a large number of stars distributed generally over the sky, and the tabular positions of the remainder would be considerably improved with comparatively moderate labour. A very necessary part of such a work would be the discussion of the systematic errors of each observatory.

AZIMUTH OBSERVATIONS.

Astronomical azimuths have been usually found by observation of circumpolar stars at meridian transit.

CONNECTION OF THE ASTRONOMICAL AND GEODETIC RESULTS.

In a triangulation such as the one under review, extending from latitude 33° to latitude 37°, and covering some 3 degrees of longitude, comparison of the astronomically determined positions with those obtained through the terrestrial measurements afford a means of estimating the form of the surface covered by the survey, and, when combined with other similar works, of determining the dimensions and shape of the earth. The consideration of this subject is, however, very largely influenced by the existence of local attraction, by which the position of the apparent zenith at any place is liable to be deflected to the extent of several seconds of arc, owing to the irregular distribution of matter in the vicinity of the point at which the astronomical observations are made, and, even where the point may from its surroundings be apparently free from any suspicion of local attraction, the apparent zenith may be displaced. As evidence of this the following passage is quoted from one of our highest authorities,* who writes :—"This amount indeed is often exceeded, and it is not uncommon to find, as in the vicinity of Edinburgh, a deflection of gravity to the extent of 5″, whilst in the counties of Banff and Elgin there are cases of still larger deflections, the maximum of 10″ being found at the village of Portsoy. At the base of the Himalayas, where we should naturally expect a large attraction, it amounts to about 30″, diminishing somewhat rapidly as the distance from the mountains increases. A very remarkable instance of such irregularities exists near Moscow, brought to light through the large number of observed latitudes in that district. Drawing a line

* Geodesy, Colonel A. R. Clarke, Oxford, 1880, page 228.

nearly east and west through the city, this line for a length of 50 or 60 miles is the locus of the points at which the deflection of the direction of gravity northwards is a maximum, amounting to nearly 6″ in the average, while along a parallel line 18 miles to the south are found the points of maximum deflection southwards. Midway between these lines are found the points of no deflection. Thus there is plainly indicated the existence beneath the surface, if not of a cavity, yet of a vast extent of matter of very small density."

The magnitude of some of the local deflections and the close accord between those arrived at by observation and those given by the triangulation of the Caucasus may be seen from the following list, which has been taken from a valuable report on gravity disturbances by Dr. Helmert.* It may be mentioned that in the same report the accuracy of Clarke's elements is amply illustrated :—

Deviation from the Vertical in the Caucasus.

Name.	Latitude.		Longitude.	Deviation from Vertical.		Difference.
	Astronomical.	Geodetic.		Observed.	Computed.	
	° ′ ″	° ′ ″	° ′	″	″	″
Pestchanovkopsky	46 14 45·81	46 14 48·70	41 6	− 2·89	0	− 2·89
Russky	45 8 1·97	45 7 52·31	41 56	+ 9·66	+ 10·83	− 1·17
Jekaterinodar	45 0 51·27	45 0 46·91	38 58	+ 4·36	+ 2·36	+ 2·00
Georgiewsk	44 9 29·27	44 9 19·30	43 30	+ 9·97	+ 12·09	− 2·12
Zubow............	43 51 22·13	43 51 21·07	46 38	+ 1·06	+ 2·65	− 1·59
Jekaterinograd	43 49 7·03	43 48 51·41	44 41	+ 12·62	+ 12·62	Assumed zero.
Alexandrowskaja..	43 29 8·13	43 28 49·99	44 8	+ 18·14	+ 19·45	− 1·31
Wladikawkas......	43 1 40·24	43 1 4·48	44 43	+ 35·76	+ 38·76	− 3·00
Petrowsk	42 59 36·7	42 59 18·14	47 33	+ 18·56	+ 16·41	+ 2·15

In our survey no attempt has been made to estimate the deflections due to irregularities in the distribution of the adjacent surface matter, owing probably to the labour involved in making the necessary topographical surveys, and also to the doubt which exists as to the radius within which such irregularities may be considered as having effect.

Allusion has been made, when dealing with the altitudes of the stations, to the advantage which would be derived from the existence of a photo-topographical survey in default of a more accurate survey, but in connection with the determination of the distribution of hill masses in the neighbourhood of the stations at which astronomical observations have been made such a survey would also prove of the highest value. In the absence of any means of correcting for the local deflections of the zenith, it is certainly

* Comptes-Rendus des Séances de la Commission Permanente de l'Association Géodésique Internationale, à l'Observatoire de Nice, 1887.

advisable to follow the plan urged by General Walker* and Dr. Gill.† The latter uses the following words :—

"The method of employing groups of neighbouring astronomical stations instead of isolated stations is unquestionably the best plan for dealing with the difficulty. Having regard to the fact that the probable discordance produced by deviation of the plumb line is far greater than the probable error of an astronomical latitude as determined by observations of a single night, it must be always more advantageous to observe for latitude on a single night at each of five or six stations in the neighbourhood of a principal point than to make a long series of observations at any one point for the purpose of securing an accuracy in the determination which is in great part nullified by unknown local attraction."

"And if this be true for meridian arcs, as General Walker's results (loc. cit.) have abundantly proved to be the case, it must be equally true for longitude stations. Every principal longitude station should therefore be surrounded by neighbouring stations for the purpose of eliminating, or at the least diminishing the effect of local attraction. The establishment of a longitude station is an incomparably more laborious and costly matter than is that of a latitude station ; it involves, for a like accuracy, a larger number of observing nights, an exchange of instruments and observers, and the cost probably of special wires, thus the labour and cost render the method practically prohibitory."

But the same end can be accomplished in a much simpler and more accurate manner by means of azimuths. Whatever information as to the amount and direction of local attraction can be derived from observations of longitude, the same information can also be derived from azimuths. If each principal longitude station was surrounded by six symmetrically placed astronomical stations, the lines joining the stations would form a regular hexagon with a central point—a figure which is the most favourable possible for accurate geodetic measurement. If the astronomical latitudes and longitudes of these points are then determined, we have, from a discussion of the discordances between the geodetic and astronomical results of the figure, all the requisite data for computing the local attraction at the central point, or rather, we secure all the advantages which would result from a group of seven latitude and longitude stations. This method would be entirely free from the objection which can fairly be brought against the use of azimuths as a substitute for longitude operations, viz., the accumulation of error which is inevitable in long chains of triangulation.

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* India's Contributions to Geodesy. by General J. T. Walker, R.E., C.B., &c. Phil. Trans., Vol. 186, pp. 778–787.

† Report on Geodetic Survey of South Africa, 1896, already cited.

"The advances made in the construction of modern instruments, and the employment of modern methods, render the execution of such a plan far less troublesome and costly than formerly would have been the case. An instrument like the 10-inch Repsold theodolite, with its observing hut and observer, can be conveniently transported in a spring-cart with a pair of trotting horses, the hooded cart forming a sleeping place for the observer when necessary."

"Taking from the data, the probable accidental error of a single measurement of the difference of zenith distance of a pair of stars as $\pm$ 0″·40, and for the probable error of the tabular declination of each star $\pm$ 0″·50 we have for the probable error of latitude, determined from the single observation of a single pair of stars.

$$\sqrt{(0{\cdot}40)^2 + 2\left(\tfrac{0{\cdot}50}{2}\right)^2} = 0''{\cdot}54$$

Thus from sixteen pairs of stars, observed on a single night, the latitude can be determined with a probable error of

$$\pm\, 0''{\cdot}14$$

a result which is at least ten times smaller than the probable deflection of the plumb-line at each station."

"The probable error of azimuth from a single night's observation, derived from all the azimuth determinations made with the Repsold theodolite at Port Elizabeth, Hanover, Kimberley, and Tygerberg is

$$\pm\, 0''{\cdot}30$$

or if the result from the azimuth determination at Port Elizabeth (the first station at which the instrument was used) be excluded, the probable error of azimuth from a single night's determination becomes

$$\pm\, 0''{\cdot}18$$

and this accuracy is abundantly sufficient."

With an instrument and observatory thus easily transported and erected (the same instrument being also available for measurement of horizontal angles) and capable of giving results of all requisite precision from the observations of a single evening, the construction of a latitude and azimuth hexagon about each longitude point would be a simple and inexpensive matter compared with the labour of and cost involved in the astronomical determinations of the longitude of the central point, and would give a sevenfold value to the geodetic results.

ASTRONOMICAL AND GEODETIC RESULTS.

In places where investigations have been made it has, however, been found that, notwithstanding such abnormal deflections of the vertical as have been referred to, a discussion of the geodetic data in connection with the astronomical observations, where these are

judiciously spread over the area surveyed, gives, as a rule, a fairly approximate value of the local disturbances. Such a discussion may therefore be concluded to afford a means of arriving at the general shape of the surface, independently of a consideration of the purely local effects, provided that sufficient observations have been made. From such a treatment the spheroidal figure best according with the measurements made in the survey of Great Britain and Ireland was determined, and a similar examination has now been made to ascertain the spheroid best representing the surface of this country.

The following tables show the astronomical latitudes, azimuths, and longitudes at the observing stations, as well as the differences between these and the similar elements deduced from the triangulation.

Geodetic and Astronomical Data.

LATITUDE.

Station.	Geodetic.			Astronomical.			G.—A.
	°	′	″	°	′	″	
Observatory	33	51	41·1	33	51	41·1	(assumed zero)
Yengo	32	59	10·24			11·23	—0·99
Warrawolong	33	2	44·89			43·90	+0·99
Maroota	33	28	3·97			5·55	—1·58
Conder	33	26	19·05			16·79	+2·26
Castle	33	42	26·28			26·93	—0·65
Base, Richd. N.	33	35	58·07			58·84	—0·77
Base, Richd. S.	33	39	44·63			44·99	—0·36
Pound	33	33	7·71			8·83	—1·12
Scott	33	32	2·19			4·33	—2·14
Bald	33	26	52·42			52·06	+0·36
Bindo	33	40	44·57			42·50	+2·07
Lambie	33	28	24·04			25·37	—1·33
Lowes	33	35	31·31			25·04	+6·27
Ovens	33	24	46·67			46·22	+0·45
Howard	33	49	13·90			18·07	—4·17
Buffalo	34	34	54·81			50·95	+3·86
Woronora	34	7	5·98			5·39	+0·59
Jellore	34	22	16·99			12·80	+4·19
Gibraltar	34	28	2·09		27	59·09	+3·00
Towrang	34	45	21·36			20·38	+0·98
Allianoyonyiga	35	2	22·57			23·50	—0·93
Base, L. Geo. S.	35	14	22·47			19·26	+3·21
Tumanang	35	45	2·24			0·98	+1·26
Umaralla	36	11	56·01			53·83	+2·18
Wambrook	36	11	35·24			36·17	—0·93
Cooma	36	15	13·40			11·94	+1·46
Hudson	36	26	35·60			35·77	—0·17
Numbla	36	37	5·74			9·12	—3·38
Bukalong	36	48	28·07			31·07	—3·00
Substitute	37	10	33·40			38·40	—5·00
Tomah	33	32	45·44			45·96	—0·52

Geodetic and Astronomical Data—*continued.*

AZIMUTH.

Line.	Geodetic.			Astronomical	G.—A.
	°	′	″	″	
Yengo—Warrawolong	99	50	2·12	3·73	—1·61
Maroota—Castle	175	48	59·12	58·60	+0·52
Castle—Red	129	30	28·84	28·76	+0·08
Base, Richd. N.—Meridian mark.	180	0	1·13	0·49	+0·64
Base, Richd. S.—Mulgoa	196	7	42·22	40·03	+2·19
Pound—Base, Richd. S.	184	52	8·79	6·10	+2·69
Bald—Tomah	122	26	32·29	31·49	+0·80
Bindo—Lambie	355	5	30·08	32·27	—2·19
Lambie—Meridian mark	179	59	57·48	60·84	—3·36
Lowes—Lambie	51	25	37·54	44·28	—6·74
Ovens—Lambie	108	48	20·89	29·54	—8·65
Macquarie—Howard	211	30	39·55	49·41	—9·86
Howard—Meridian mark............	179	59	51·08	59·16	—8·08
Narrawa—Buffalo	228	4	24·22	29·86	—5·64
Buffalo—Meridian mark	179	59	56·32	62·16	—5·84
Gannon—Potts	316	53	0·38	1·70	—1·32
Gibraltar—Meridian mark	179	59	45·31	43·01	+2·30
Allianoyonyiga—Meridian mark..	180	0	1·12	— 0·26	+1·38
Base, L. Geo. S.—Meridian mark.	179	59	59·54	57·02	+2·52
Umaralla—Hudson	218	4	42·58	32·24	+10·34
Wambrook—Clear	25	10	17·01	10·13	+6·88
Hudson—Umaralla	38	13	8·29	0·89	+7·40
Numbla—Hudson	62	19	27·11	19·17	+7·94
Bukalong—Substitute	182	56	18·32	9·77	+8·55
Substitute—Tingi Ringi	295	30	26·84	14·91	+11·93

LONGITUDES.

Station.	Geodetic.			Astronomical.			G.—A.
	°	′	″	°	′	″	
Howard	149	3	20·460			17·505	+2·955
Lambie.........................	149	59	24·600			25·800	—1·200
Cooma	149	4	47·384			50·10	—2·716
Observatory	....			151	12	23·10	(assumed zero)

It may be here remarked that in the latitude observations the annual variation of latitude has not been allowed for ; as, although its existence has been verified, its amount and period cannot as yet be considered as ascertained.* Effect from this cause upon the results obtained in the calculations about to be referred to will, however, be inappreciable.

* Since the above was written, Dr. Chandler's determination of an expression for the variation of latitude has been published. Dr. Chandler's value seems likely to need little f any modification, but it has not yet been used here.

RELATION BETWEEN ASSUMED AND ACTUAL SURFACES.

It may be shown that the effect of projecting the points of a triangulation upon a spheroid of reference which must, by the method of the problem, differ only slightly from the actual spheroid, will produce differences which are only of the second order in comparison with the inclination of the surfaces to each other, and further, that these differences are so small as to be overwhelmed by other sources of error. Supposing, therefore, that ξ and η are the inclinations between the surfaces at one point, ξ in the direction of the meridian, and η in a plane at right angles thereto, we are enabled by a comparison of the astronomical and geodetic positions to express the ξ' and η' belonging to any other point in terms of ξ and η, and, by determining a set of elements for the earth's figure, such that the sum of the squares of all the ξ's and η's is a minimum, we arrive at the most probable shape of the surface. From this treatment there result for the latitude, longitude, and azimuth observations, equations of the following forms :—

$$\xi' = \kappa + A\,\xi + B\,\eta + C\,u + E\,v$$
$$\sec\phi'\,\eta' = \kappa' + A'\,\xi + B'\,\eta + C'\,u + E'\,v$$
$$\tan\phi'\,\eta' = \kappa'' + A''\,\xi + B''\,\eta + C''\,u + E''\,v$$

in which u is a correction on the assumed value of the major semi-axis, and v a correction on the eccentricity of the elliptic meridian.

DIMENSIONS OF MOST PROBABLE SPHEROID.

Sixty-eight equations of the above form have been obtained, from which, allowing the same weight to the longitude and azimuth equations as to the latitude equations, normal equations are got by the method of least squares, the solution of which gives the following values :—

$$\xi = -0{\cdot}45''\,;\ \eta = -1{\cdot}39''\,;\ u = +0{\cdot}550\,;\ v = +1{\cdot}518.$$

With these values the elements of the spheroid would appear to be :—

$$a = 6974378 + 1861 \text{ yards}\,;\ e^2 = {\cdot}0073875.$$

From an examination of the data we would be led to expect that certain systematic influences would to some extent affect this result, for it will be seen that in following the triangulation net westerly from the Richmond base the Dividing Range is crossed, and at all stations between Bindo and Buffalo the general influence of the mountain mass is shown by an easterly deflection of the plumb line ; also in the southerly extension from the Lake George base a similar deflection of opposite sign is shown, resulting from the triangulation being located on the eastern slope of Monaro with the high mountain mass culminating in Mount Kosciusko, the highest point in Australia, lying to the westward.

Again, too, the question of the relative weights of the azimuth and latitude observations are to be considered. It must be admitted that the equations to the latitude should have greater weight than either those connected with the azimuth or with the longitude observations, having in view the facts that in the azimuth equations are contained any errors occurring in the transfer of directions through so many different points, and that from the nature of the longitude observations results of like precision to those given by the latitude observations cannot be looked for. The actual determination of relative weights to be applied to each is, however, somewhat difficult of solution, and must, to a large extent, be a matter of opinion. As judged though by the very small errors of closure of the triangles, it would seem that the error in carrying on azimuth must be relatively small, and that the difference of weight to be assigned to the different classes of data should not be so great as would, at first sight, appear to be demanded.

Allowing half weight to the azimuth and latitude observations, and omitting those azimuth observations which have been above referred to as being influenced by systematic attractions and likely to unduly affect the results, it is found that the values of ξ, η, etc., become

$$\xi = -0{\cdot}44'', \eta = -0{\cdot}93'', u = +0{\cdot}395, \text{ and } v = +1{\cdot}147.$$

From these are obtained—

$$a = 6974378 \text{ yards} + 1336\,;\ e^2 = {\cdot}0072080.$$

These elements, it will be seen, more closely approximate to those which were assumed for the spheroid of reference, and it is not unlikely that even closer agreement will result from the further extension of our triangulation northward.

It is necessary to add that all lengths arrived at are in terms of the standard bar used in the base measurements, the length of which, in comparison with the standards of other countries, as has been before mentioned, is well determined by Colonel Clarke's observations. The information respecting such comparisons is of great value, for it will enable the triangulation of this Colony, which is in a latitude peculiarly favourable for the purpose, to be combined with those of Europe, where the subject receives considerable attention, surveys of high precision being now extended over the whole of that continent. While the results given above may be expected to indicate with fair precision the shape of the surface covered by this survey, combination with those of other countries is necessary for obtaining a fair value of the dimensions of the earth as a whole.

No account of this survey would be complete which did not pay some tribute to the skill, as an observer, of the late Mr. W. J.

Conder, to whom is due in a great measure the high degree of precision attained. The names of Messrs. P. F. Adams, late Surveyor-General of the Colony, and H. C. Russell, C.M.G., F.R.S., must also be recorded in any such sketch as this. To the former the very existence of the survey is in a large measure due, and it owes much also to his wide practical knowledge and experience, while the latter has, during its whole progress, aided in many ways where his scientific attainments were of the greatest service.

QUEENSLAND.

The extent of the triangulation effected in Queensland is shown by the accompanying map (marked F) from which it will be seen that it covers nearly 3 degrees of latitude and 2 of longitude. Unfortunately the further progress of the survey is held in abeyance, having been stopped some few years back, when the position of public and private finances alike demanded the stoppage for the time being of all expenditure not absolutely necessary for the maintenance of existence. As, however, our northern neighbours now find themselves in as prosperous a condition as they were then in the reverse, it is possible that this work, which is agreed on all hands to form one of the best means of securing economy in land administration, will be shortly resumed.

The base line from which lengths are derived is situated at Jondaryan (see map), its whole extent of about 7 miles being divided into ten sections. It is upon an open plain, the terminals of which, Mounts Irving and Maria, are respectively 216 and 162 feet above the general level of the remainder. It was originally proposed that measurement should be confined to the plain, extension east and west to the hills named to be made by triangulation ; but experience gained in the measurement showed that the system adopted was capable of satisfactory application to the inclined parts of the line, and the slopes were accordingly measured also. The length was determined by two steel tapes, each 100 feet long, which were compared with a steel bar floating in mercury, carefully standardised by measurement against the standard bars of New South Wales.

This bar had in 1883 a length of 9·9998581 feet at a temperature of 62° Fahrenheit, but subsequent reference (in 1895) to the New South Wales bars would make it appear as though the Queensland bar was slowly shortening. The tapes were contained by wooden troughs to protect them from the sun and wind the troughs resting on pegs placed so as to follow the general slope of the ground, which was measured and allowed for in the computations. The tapes were kept at a constant tension of 20 lb. during use, and temperatures were obtained from five thermometers distributed along the length of the tapes, it being

estimated that the adopted temperatures are probably not more than one-fifth of a degree in error. Marks were made in copper discs inserted in wooden pegs driven into the ground at each 100 feet, the distances between the tape-ends and the marks being measured by micrometer microscopes. Three measurements were made with each tape, each one distinct and independent, so that every section was measured six times. For the whole base the difference between the means of the three measures with each tape amounted to 0·117 of an inch ; a slightly greater difference than this was, however, observed in the corresponding measures of one of the sections—section 5. The lengths of the various sections were compared by triangulation, and calculating one-half of the base from the measurement, a difference of ·936 of an inch was shown. The base-line work was executed by Mr. A. McDowall, the present Surveyor-General of Queensland, assisted by Mr. R. Hoggan.

The instruments used in the angle measures were generally 10-inch theodolites by Troughton and Simms, read by two micrometer microscopes to a second of arc, but at a few of the stations a 12-inch instrument by the same makers was employed. From two to eight readings were made on each of eleven different parts of the graduated arc, the mean of the means in each position being used. The following are the closing errors of the seventy-four measured triangles :—

Closing error.	Number of triangles.
$0''$ to $1''$	29
$1''$ to $2''$	29
$2''$ to $3''$	11
Upwards of $3''$	5

The maximum error of close was $3''·90$, and, computing m from $m=\left(\frac{\Sigma\Delta^2}{3n}\right)^{\frac{1}{2}}$ it is found to be $(\pm)$ $0''·95$. The triangulation has been calculated with elements given by Colonel James in the account of the Ordnance Survey of Great Britain in 1858.

The astronomical datum is the position of the station at Jimbour, as determined by Captain Morris, R.E., and Lieutenant Darwin, when observing the Transit of Venus in 1882, the longitude being measured by telegraphic exchange of time signals with Sydney. Astronomical observations have been made at stations, Bloodwood, Brisbane, Haystack, and Mount Domville. The geodetic latitudes of these stations, minus the astronomical positions, give the results $-·02$, $+1''·17$, $+5''·37$, and $-1''·17$, respectively, and the similar differences for the longitudes of the first two of the stations named are $+6''·57$ and $-·05''$. The azimuth datum was observed by meridian transits of circumpolar stars at station Bloodwood, and the latitude of the same station

was obtained by the Talcott method of zenith pairs, the other latitude determinations being by measurement of circum-meridian altitudes, and by prime vertical transits. In addition to the astronomical observations at the stations connected with the triangulation, observations have been made to determine the latitude and longitude of a number of other points, distributed over the area of the colony, and shown on the map marked F.

In connection with the survey of Brisbane a triangulation has been made from a base 1,924 feet long, laid down in the Botanical Gardens. The base was measured twice with one of the tapes mentioned as being used on the Jondaryan base, and once with the other of the same tapes, a fourth measurement being made with a new tape. The angles were measured with 10-inch and 6-inch theodolites, and connection with the main triangulation shows differences of four seconds in azimuth, and about four-fifths of an inch per mile in length, representing a difference of about three-tenths of an inch in the length of the Brisbane base.

The whole of the triangulation was in the executive charge of Mr. R. Hoggan, who was assisted by Mr. R. McDowall.

VICTORIA.

The trigonometrical survey of Victoria was preceded by a system of laying out on the ground, meridians and parallels of latitude, by which it was expected to rapidly meet the demand for land, which in 1857 the Survey Department found itself unable to cope with. The intention was to surround large areas by carefully fixed meridians and parallels, to subdivide these again into blocks of one-tenth of a degree in each direction, the further subdivision for alienation purposes being effected by contract. This work was begun in 1858 under the direction of Mr. R. L. J. Ellery, C.M.G., F.R.S., etc., the difference of longitude between Williamstown Observatory and the first meridian line being laid out on the ground by triangulation.

The general course followed was to determine the direction of the true meridian by means of a transit instrument or an 18-inch altazimuth, placing marks in the direction of the true north and south at the greatest distances commanded by the observing station. These varied from 5 to 20 miles, but intermediate points were also marked where possible, the whole line being subsequently run and, if on Crown lands, cleared and marked. For the chaining, the ordinary 66-foot chains were used, but distances were controlled by a subsidiary chain of triangles with sides of from 2 to 5 miles length, carried along the line from carefully measured bases. The intersections of parallels with the meridians were marked, and the parallels laid out both by offsets from chords and from tangents at right angles to the meridian lines,

lengths along the parallels being, as with the other lines, checked by triangle chains, the angles of which were measured with 8-inch and 10-inch theodolites.

After a considerable amount of this work was done, it was found that it was not proceeding expeditiously enough to meet the calls upon it, principally because of the inadequate funds set apart for the conduct of the scheme, and it was resolved to carry on a primary triangulation so as to reach the more distant parts of the colony, advantage being taken of a number of trigonometrical stations having been marked for such a purpose a few years earlier by Captain Clarke, R.E., the then Surveyor-General.

In 1860, therefore, a base nearly 5 miles long was laid down on the Werribree Plains, and measurement was made between January and May of that year, an extension of the base of triangulation to Green Hill, making the total length over $5\frac{1}{2}$ miles, being effected shortly afterwards.

The actual measurement was made by the use of three iron rods, the lengths of which were ascertained by micrometer comparisons with the 10-foot ordnance standard lent by the New South Wales Government, a similar standard for use in Victoria being subsequently obtained from the Ordnance Survey Department in England. The bars were fitted with steel ends, one flat and the other rounded to form a section of a sphere of 5 feet radius. They were used by being placed in series, with distances of about $\frac{1}{4}$ of an inch between the spherical end of the one and flat end of the adjacent one, the distance of these two apart being obtained by passing a wedge between them until contact with each other was made, the position of the wedge at the time being read by graduations made along its length. The wedge was of hard bell-metal, 7 inches long by 2 broad and the inclination of the faces was 30 minutes. The bars were kept level during the measurement, change of height being seldom needed, as the difference of height of the two ends of the base was only about 14 feet. A re-measurement of part of the southern end was made following the slopes of the ground, and on reduction the co-incidences were such as to justify the assumption that by the original measurement, the Werribree base was probably as accurate as any measured up to that time. The total difference between the two values for the southern part was 0·308 inches, or about 0·15 inches per mile.

The terminals of the base were marked in a substantial manner, and immediately on its completion, triangulation was carried therefrom to the Western district by Mr. A. C. Allan, Messrs. Penniger, Black, Petty, and others being similarly employed in other districts. Considerable activity was shown for some time, the greater part of the colony being within a few years covered with a first class series of triangles, the last operation of the staff being the demarcation in 1872 of the straight line from the

Murray to Cape Howe, forming the boundary between the colony and New South Wales. Upon this work, Messrs. Allan and Black were engaged, the triangulation for this purpose being extended to include "The Pilot" and Mount Kosciusko in New South Wales. The triangulation connecting the ends of the line having been observed, the line itself was ranged on the ground to the calculating bearing with the gratifying result that it reached the coast within 17 inches of the marked terminal, a fitting tribute to the skill, energy, and endurance of those in whose hands the work had been placed.

SOUTH AUSTRALIA.

The first trigonometrical survey work in South Australia was that commenced in 1840 by Colonel Frome, R.E., Surveyor-General of the province, who, in the course of the three years following, observed a network of triangles extending over the hilly country—east, south, and north of Adelaide—from Encounter Bay to the head of Spencer's Gulf. His base was measured on the Adelaide Plains, west of the city, six independent measurements being made; the instruments used being a heavy steel chain of 100 feet length, and a lighter one 66 feet long, with brazed rings. The adopted length of the base was 17,462·20 feet. Only one end of it can now be identified; but the brass standard then used for reference is still in a good state of preservation at the Surveyor-General's Office in Adelaide.

Observations for determination of the true meridian were made at four stations, with an altazimuth of English make, by J. D. Potter, having a horizontal circle of 13 inches and a vertical circle of 6½ inches. Latitudes were found by meridian observations of the sun and fixed stars with the sextant, and several sets of lunar observations were also taken for longitude. The horizontal angles were almost all taken with 5-inch "Y" theodolites, reading only to minutes. Six or eight rounds of angles were observed (as instrumental bearings increasing towards the right hand) at important stations, and three rounds for subsidiary triangles, the vernier index being set differently for each consecutive set. Reciprocal angles of elevation and depression were also observed to the tops of all the stone piles which mark the stations, thus enabling their elevation above sea level to be calculated. The sides of the triangles range from about 6 to 16 miles, and the closing error of each from 3 to 10 seconds.

Work of a similar character was carried out from 1857 to 1860, under the direction of Colonel Freeling, R.E., Surveyor-General, when, in order to fix the positions of pastoral leases in various localities, over 100 miles apart, several base lines were measured with ordinary surveying chains. Thus separate systems of triangulation grew from these bases, which, while securing

their purpose satisfactorily, and possessing the merit of economy, were not connected in such a manner as to allow of exact comparison of their respective base lines.

The instruments used on these surveys were 7-inch theodolites, three rounds or sets of instrumental bearings were required to be taken with the vernier set at 360°, 120°, and 240° respectively. The length of the sides of the triangles ranged from 10 to 40 miles, and the closing error in some cases was as high as 15″.

Shortly after Mr. G. W. Goyder's appointment as Surveyor-General, the triangulation of the Eastern Plains and Gawler Ranges was completed.

In 1873 by the exertions of Mr. A. B. Cooper, Deputy Surveyor-General, the survey of the outlying districts was continued upon strictly geodetic lines, the forms of record and methods of astronomical observations adopted being similar to those of the Victorian Geodetic Survey. This class of work has been continued uninterruptedly for twenty years covering about 1,000 miles of country. Seven-inch theodolites have been chiefly used since 1873, but good work giving errors of only one or two seconds per triangle has been done with a smaller German theodolite by "Ertel," having four verniers and an excellent telescope.

The latest base line was measured during 1880 on a level flat 500 miles north of Adelaide. It was measured eight times with deal bars, 10 links in length, brass capped, and twice with a steel bar of the same length, all standard according to the brass yard previously referred to. Numerous stout stakes were driven into the ground in perfect alignment and to the same level; a copper tack was inserted into every stake, and upon these the bars were rested, and a fine line drawn at the end of each. Two sets of measurements were made in summer and two in winter, corrections for temperature being carefully applied. But the wooden bars were found to shrink more than $\frac{1}{100}$ of an inch, involving continual uncertainty. The length given by the steel rod alone, viz., 9,107·71 feet was, therefore, adopted. While the line was in process of measurement, angles were taken at appropriate distances to stations on neighbouring hills which afforded facilities for extending the line.

Astronomical latitudes have been determined by meridian passage of stars with both transit theodolite and sextant, which differ from the calculated positions by from 2 to 16 seconds. Some of these discrepancies are doubtless owing to deflection of the plumb line, as the altitude of the country varies from a few hundred to over 4,000 feet above sea level, but no systematic effort has been made to determine the extent of disturbance due to this cause. The observations for azimuth are taken at every second or third station, either with a 7-inch "Y" or a smaller transit theodolite; a set consists of six or eight observations of

circumpolar stars, many of these disagree with the calculated bearings by nearly a minute either way, the cause of which is believed to be largely due to an imperfect motion of the telescope in the vertical plane, although precaution is taken to reverse the alidade of the "Y" theodolite at each observation, and to change the pivot ends of the cross axis of the telescope every alternate observation made with the transit theodolite.

For the purposes of calculation the angles of every triangle have been made to sum 180° plus their spherical excess by adopting the arithmetical mean of the best observed values, and solved as plane triangles. Only in special cases has the method of "least squares" been applied.

The greater part of the triangulation has been co-ordinated in portions for plotting purposes upon different planes, the meridians for which are connected with initial meridian of the Adelaide observatory; and a wide circuit of geodetic latitude, azimuth, and longitude has been computed from these, Clarke's elements of the spheroid being used for the purpose.

In process of co-ordination it becomes evident that a polygonal figure of about a dozen sides, comprising a surface of 500 square miles or more, may be selected from any part of the more recent work, of which the angles, if mathematically treated, will not be found more than 5 seconds in error.

The trigonometrical survey of South Australia now embraces about 175,000 square miles, having its greatest length in latitude 27°, stretching from the boundary of New South Wales to that of Western Australia, 740 miles, and between the parallels of latitude 36° and 26°, 688 miles upon the meridian of 139° east longitude.

Particulars of Base Lines.

Locality.	Length in feet.	Date.
On the Adelaide Plain	17462·20	1840
Near Mt. Serle	10560·00	1857
N.E. of Port Augusta	23189·70	1859
N.E. of Lake Torrens	105861·90	1860
Near Mt. Margaret	58423·20	1860
Eastern Plains	42461·76	1862
500 m. N. of Adelaide	9107·71	1880

From the above short account, which has been forwarded by Mr. W. Strawbridge, the present Surveyor-General of that colony, for the purposes of this paper, it will be seen that South Australia possesses a survey, the character of which speaks well for those in whose charge it has been placed. Though not, perhaps, carried out

with all the precision necessary for the determination of the figure of the earth, yet for all the purposes, and they are many, of the management of the Crown estate, it is of the highest value. Its limits are indicated roughly on the map marked D.

WESTERN AUSTRALIA.

The trigonometrical surveying done up to the present in Western Australia consists almost entirely of long chains of triangles, embracing a very large extent of the western sea-board, and in some cases extending to a considerable distance inland. The section between Fremantle and Geraldton was observed some twenty years back, but the bulk of the remainder has been carried out during the last seven or eight years. Owing to lack of the slight additional means needed for undertaking an adequate survey, the angles have been measured only with small instruments, generally 6-inch theodolites, reading to 30 seconds, though at some few places 8-inch theodolites, reading to 10 seconds, were used.

Work of this character, if viewed as preliminary to a survey of a better class, no doubt serves a useful purpose, as affording a frame-work on which to build the rough maps required in the early stages of the settlement of so vast a territory. It, however, cannot fulfil properly that function of a triangulation which, from an economic point of view, may be considered as one of the main ones, namely, serving as a check on the field work, so as to reduce to a minimum the cost of field inspection of the chain surveys. To serve that purpose it is imperative that the trigonometrical survey should be indisputably better than the work it is to control. From another point of view, also, it is to be desired that, if undertaken at all, a trigonometrical survey should be carried out with greater precision. The question of the calculation of the triangulation itself is what is referred to, for in work of such approximate nature it cannot but be found that on joining between the different bases and astronomical stations, discrepancies of length, azimuth, and position are shown of such magnitude that their proper distribution is beyond the reach of any systematic method of adjustment, so that appeal has to be made to some arbitrary means, always a most unsatisfactory resort.

Six bases have been measured, viz., at Perth, Wyndham in the Pilbarra District, and on the Fitzroy and Ashburton Rivers. Their lengths were obtained by the use of steel wires, 66 feet long, fitted with knife edges at the ends, changes of temperature being observed during the measurement, and allowed for.

Astronomical observations were taken at points about 200 miles apart, latitudes being determined by meridian altitudes of stars and azimuths by observation of circumpolar stars at their

greatest east and west elongations, but the instruments used were only the same small ones employed in the terrestrial work. The time is looked to, however, when the whole of the survey will be the object of a little more consideration from those in charge of the purse-strings, so that this extensive triangulation, which now, with only one small gap, covers nearly 19 degrees of longitude and 17 of latitude, may be made available not only for all the needs of land administration, but also may be made to contribute to our knowledge of earth shape and size.

TASMANIA.

The trigonometrical survey of this colony may be said to have been initiated in 1849, when the first measurements were made of a base line, nearly 4 miles in length, at Ralph's Bay. Rods of fir, each 15 feet long, protected by a covering case and insulating material, and fitted with brass caps at the ends, were used, and the general slope of the ground was followed, corrections for the inclinations of the rods being applied. The brass caps of the ends of the adjacent bars were brought side by side, and a scale fitted to one was read by a vernier engraved on the cap of the next bar. The lengths of the rods were ascertained by comparison with a 4-foot steel standard divided into inches and fortieths, comparisons being made from time to time during the operations. This was, at the time, the only standard in the colony; but shortly afterwards a 10-foot steel bar was obtained from England, and on the older one being compared with it, the two were found to be in such very close agreement, that Major Cotton stated in a report of his on the subject in 1852, that the measurement required no reduction on this account.

This later standard was one of those employed in base-line measurement for the Ordnance Survey of Ireland. Its length, therefore, may be assumed to have been well determined. The same base was afterwards measured twice in 1851, when the earlier results were found to differ from the mean of the later, by about 10 inches; the mean of the later determinations, over which greater precautions had been taken, and which differed only by slightly more than an inch, was adopted.

A base of verification nearly 5 miles long was measured twice by similar means, at Longford, on the Norfolk Plains, the two measures differing only by $3\frac{1}{2}$ inches. The bases, which were about 100 miles apart, were connected by a system of triangles, the angles of which were measured by repetition with a 12-inch altazimuth graduated to 10 seconds. The greatest error of close on this system was $3''\cdot3$, a result which points to the accuracy of the instrument and to the care taken in making the observations. A further proof of the accuracy of the work is given by the fact

that the measured length of the Longford base was found to differ only $3\frac{1}{2}$ inches from that derived through the triangulation from the original base. The principal triangles of this system are very well conditioned; but the same cannot be said of those by which connection is made with the bases. A large number of other triangles were observed with the same instrument, the error of close generally not exceeding 2 seconds, and at every principal station angles of elevation and depression were observed for determining the heights.

The datum for the calculation of positions is at Hobart, the latitude and azimuth at this point being determined by observations of σ Octantis, and by observations of a number of other circumpolar stars at greatest elongations. At four other stations the latitudes and azimuths were determined simultaneously by elongation observations, the differences between the observed and geodetic results being as follows :—

Station.	Astronomical Latitude.	Geodetic Latitude.	Difference = G—A.
	° ′ ″	° ′ ″	″
Dromedary	42 42 38·8	42 42 38·27	— 0·5
Brown Mountain	42 36 7·7	42 35 48·67	— 19·0
Table Mountain	42 14 28·9	42 14 7·43	— 21·5
Miller's Bluff	41 56 18·2	41 56 1·13	— 17·1

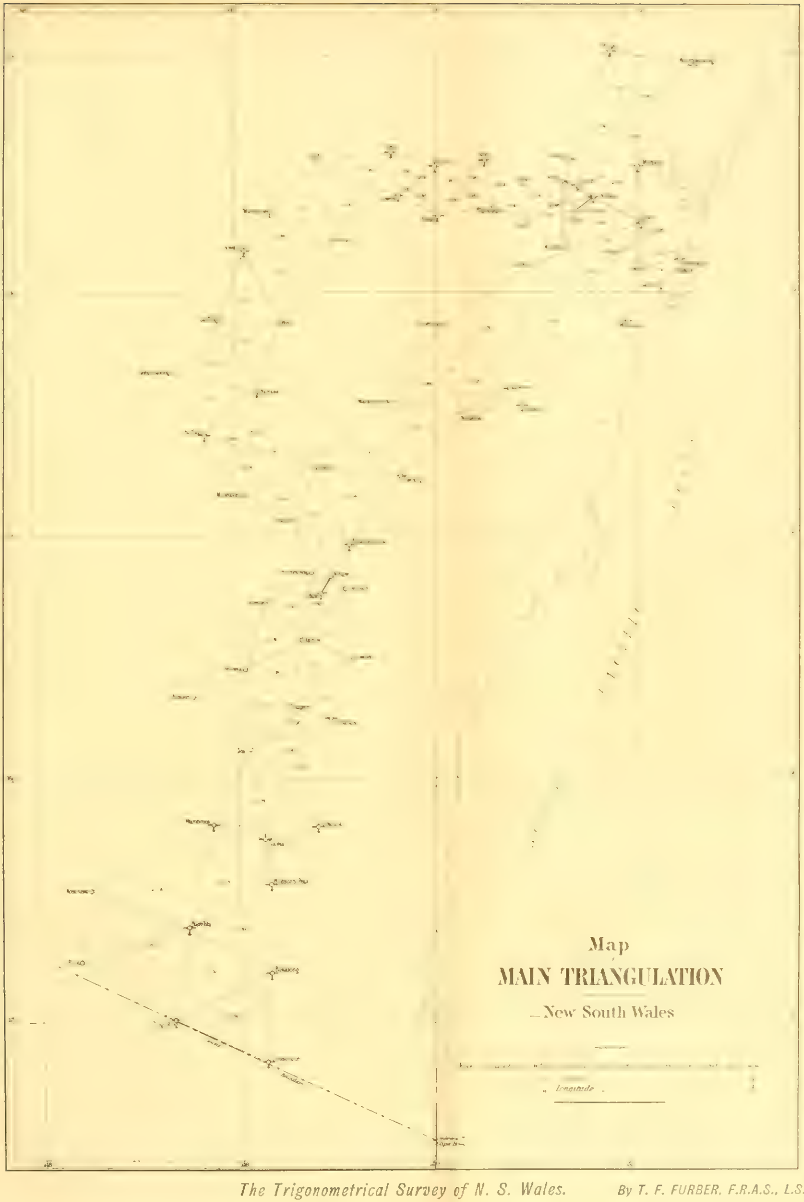
Lines.	Astronomical Bearings.	Geodetic Bearings.	Difference = G—A.
	° ′ ″	° ′ ″	″
Dromedary—Brown Mountain	69 23 19·4	69 23 30·8	+ 11·4
Brown Mountain—Table Mountain	321 30 11·8	321 30 33·2	+ 21·4
Table Mountain—Brown Mountain	141 46 13·2	141 46 21·4	+ 8·2
Miller's Bluff—Table Mountain	184 52 21·0	184 52 35·5	+ 14·5

The method of latitude determination was not the most satisfactory, but modification of the results on that account would necessarily be small as compared with the above differences. It would thus appear that either the elements of the earth's figure

assumed in the computations do not well represent the surface of Tasmania, or that there are considerable local deviations of the vertical. Possibly both these causes contribute in some degree; the latter may certainly be expected to have effect from the rugged nature of the country covered by the survey. The writer is unaware of the elements adopted, but in some of the computations appended to Major Cotton's account of the triangulation, read in 1855 before the Royal Society of Tasmania, and from which much of the above information has been drawn, a mean radius of 20,887,457 feet has been used. The whole of the survey, it should be stated, was executed by Mr. J. Sprent, under Major Cotton's direction.

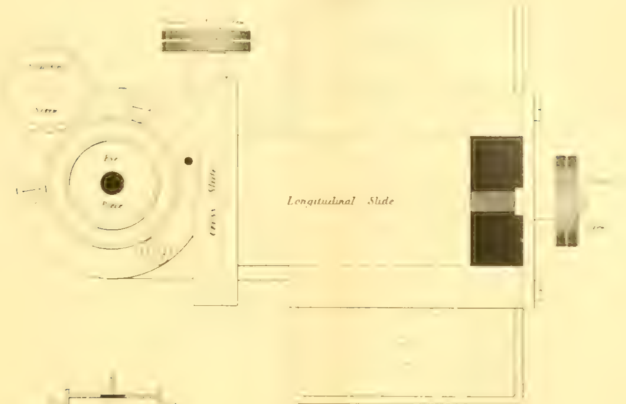
For some thirty years or more no other application of the trigonometrical survey appears to have been made, than by its aid to construct a framework for the projection of a map of the Colony, and on one occasion at least its general accuracy has been assailed, for reference may be found in the Tasmanian Royal Society's Proceedings, as lately as the year 1881, to its having been challenged by the late Mr. Calder, a former Surveyor-General of the Colony. However, the opinion expressed by Mr. Black, of Victoria, when, in 1883, reporting on the system of surveying in Tasmania, seems a most feasible one. His view was that "It is quite possible that the erroneous character of much of the topography of Mr. Sprent's map may have given rise to the impression that the whole data is worthless; but it by no means follows that this is the case because some person evidently imperfectly acquainted with the country has sketched the features incorrectly."

Some attempt has recently been made to put the triangulation to some service, and during the years 1884–6 some forty of the stations were rebuilt. Many others, however, are, it is understood, not now recoverable. The cause of its having fallen into desuetude was no doubt the fact that it was not combined with a sufficient amount of minor triangulation to enable proper connection of the chain surveys to be made, without having to run traverses for long distances, and often into country presenting the greatest difficulties in the way of chaining. The advantages offered by a trigonometrical survey have now been fully recognised, and some five base-lines have been measured for the purpose, doubtless, of carrying out any future extensions on the New Zealand scheme of initiating purely local systems which become eventually joined into one comprehensive survey of the whole country.



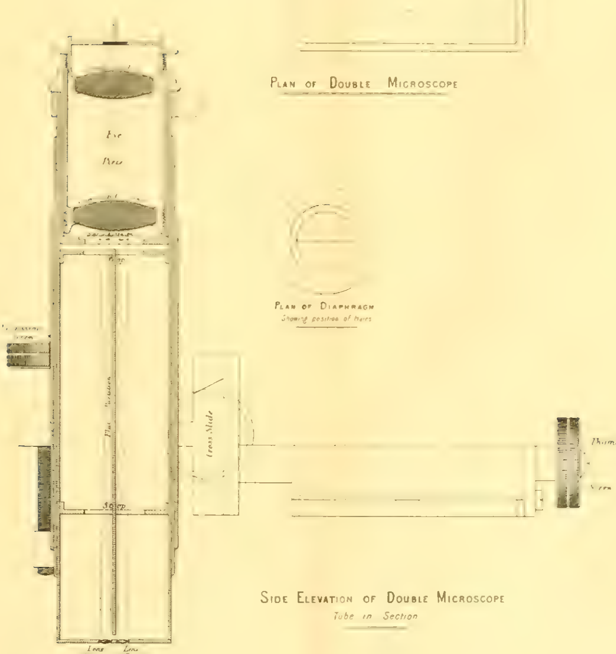
The Trigonometrical Survey of N. S. Wales. By T. F. FURBER, F.R.A.S., L.S.

"B."



PLAN OF DOUBLE MICROSCOPE

PLAN OF DIAPHRAGM
Showing position of hairs



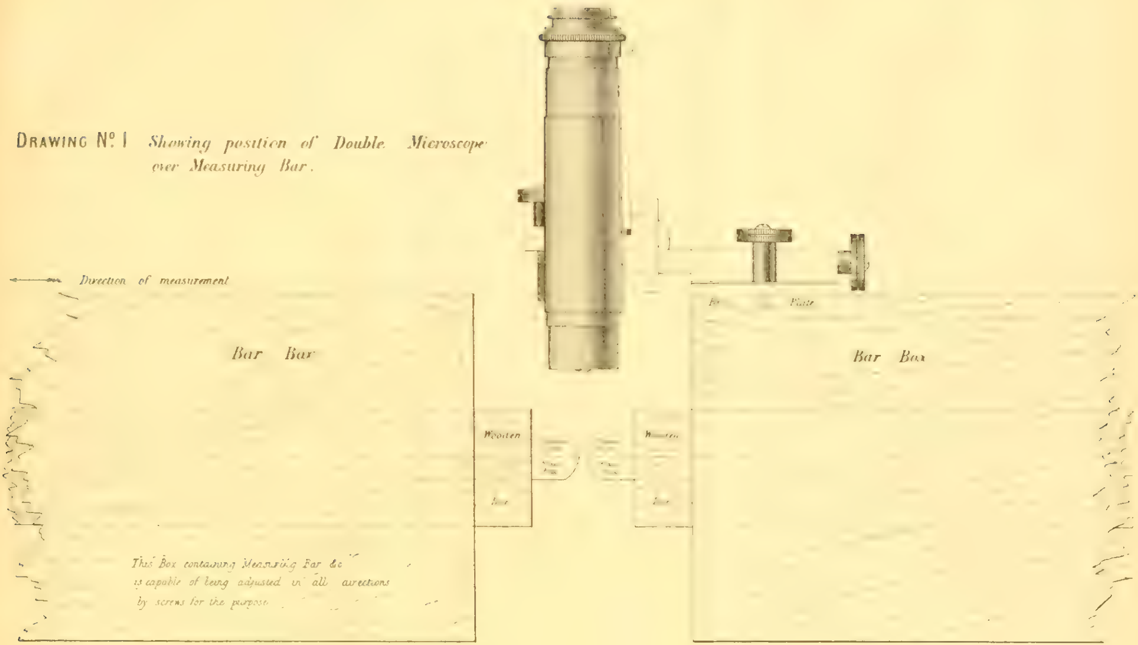
SIDE ELEVATION OF DOUBLE MICROSCOPE
Tube in Section

The Trigonometrical Survey of N. S. Wales.

By T. F. FURBER, F.R.A.S., L.S.

"B."

DRAWING No. 1 *Showing position of Double Microscope over Measuring Bar.*



The Trigonometrical Survey of N. S. Wales.

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By T. F. FURBER, F.R.A.S., L.S.

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The Trigonometrical Survey of N. S. Wales.

By T. F. FURBER, F.R.A.S., L.S.

The Trigonometrical Survey of N. S. Wales.

By T. F. FURBER, F.R.A.S., L.S.

No. 5.—DESCRIPTION OF A TIDE-PREDICTING MACHINE.

By CAPTAIN A. INGLIS.

(*Read, January* 10, 1898.)

THIS machine differs from any other one that I know of in its requiring only one set of gearing. The principle on which the machine is founded is as follows:—A number of wooden templates are cut, each in the form of a sine curve, representing one of the tidal components; these waves are of different lengths, but are all pushed along vertically side by side at the same rate, being supported by a frame or carrier moved forward by a rack and pinion. A number of vertical plungers rest in a line on the top of these templates, and are moved up and down as the curves progress forward. The motion of the plungers are then compounded by means of a fine wire passing over pulleys at the top of each one, and under fixed pulleys between adjacent ones. The compound portion is then communicated to an indicator, which moves up and down alongside a vertical scale. The forward movement of the carrier on components moves the clock, which indicates the time. Thus the time and height can be read off at once.

GENERAL DESCRIPTION.—The machine consists of a rectangular frame, 4 feet long, 29 inches wide, and 10 inches high; in the lower part of it is a groove in which the carrier moves. Across the top at the middle of the frame is a beam with vertical slots in it for the rods or plungers to move up and down in, between each slot in the beam a pulley is fixed. In front of the beam is the recorder with a scale on it, in this recorder is a traveller, which carries a pencil on one side and pointer on the other, the one for tracing the curve and the other for showing the height on the scale. In front of the frame, between it and the recorder, is a vertical slide holding the paper on which the curve may be traced. The carrier is a flat frame with grooves in the upper part of it, in which the curves or templates representing the different components are fixed. On the lower side is a rack, which, when acted on by a pinion, gives the carrier a rectilinear motion through the frame. Underneath the carrier, and across the frame, is a shaft with a crank outside. On this shaft three pinions are fixed; these give motion to the carrier, vertical slide, and the clock respectively. The clock is fixed on top of the frame above the shaft.

The curves or templates are each cut to represent a tidal component, according to its wave length or speed. They are on the scale of 1 inch to the mean solar hour (15°) and 1 inch to the foot in amplitude, and are true sine curves. The wave length of each component bears the same ratio to the solar tide, S2, as its angular speed does to 15°.

The rods or plungers have each a pulley on the upper end, and a hard smooth point on the other. They are placed in the slots in the beam already mentioned, the lower end of each resting on a component curve; and we have already seen there is a fixed pulley in the beam between each rod. A fine flexible wire is passed under each pulley in the beam, and over each one on the rods, through another in the recorder, and back through a larger fixed pulley at the back end of the beam, then the two ends are joined, thus forming and endless wire.

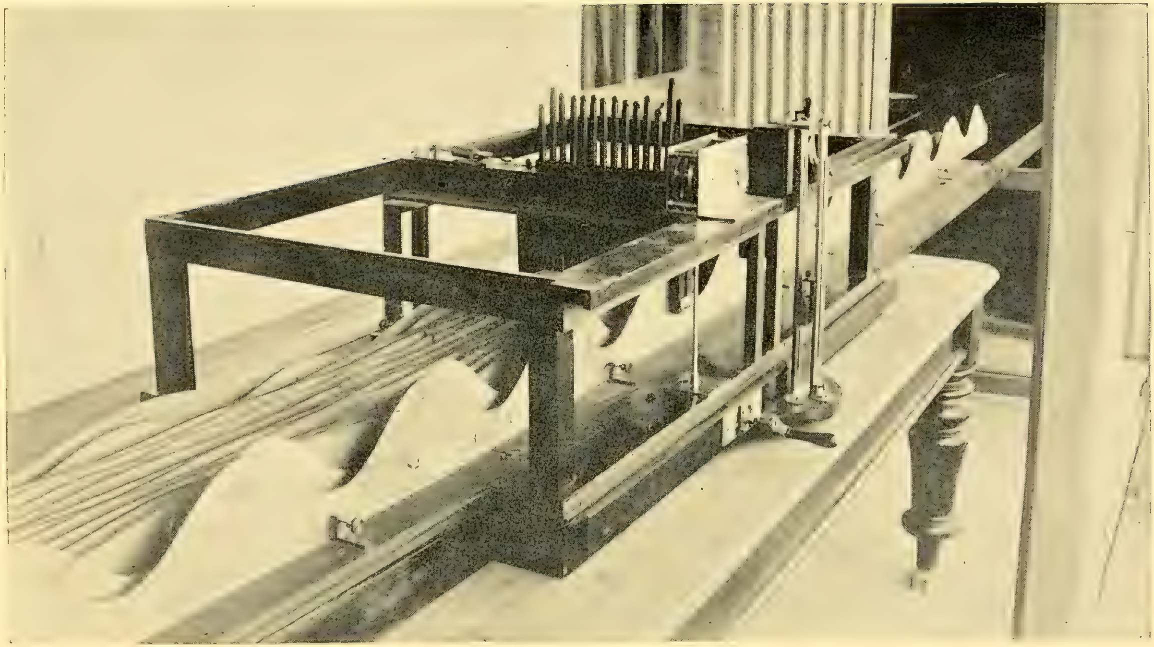
The larger pulley just mentioned is fixed to a plate, which is movable backwards and forwards, for adjusting the index to the mean level of the sea. The pulley is attached to the plate by a fine screw, by which means a compensation is effected for the annual and semi-annual tides, the amplitudes of which are treated as constants for fourteen days, and graduations are made on the plate for that purpose.

The machine is designed for twenty-three components, although only sixteen have been used, the amplitude of the others being so small that they may be neglected without any material error.

Each template or curve is fixed in the carrier at the proper place according to its phase, that is, the first high water of each component tide is placed a certain distance from the epoch or starting point, determined by the previous harmonic analysis. The handle being turned, the carrier, verticle slide, and clock are set in motion, and the curves passing underneath the rods give them a vertical harmonic motion, which is communicated to the index by means of the endless wire. The pointer will then show the height of tide at the time indicated by the clock, and the curve will be traced on the paper attached to the vertical slide.

It will thus be seen that the machine continuously sums the series and traces the curve.

The chief feature of this machine is that all the curves move together at the same rate; the differences in speed being obtained by the difference in the wave-length of the curves. After the curves are once set, the working of the machine is very simple, all that is required being to turn the handle and watch the pointer; when it stops rising it is high water, the time and height can be read off and recorded at once. The same thing applies to low water. If, as may be the case at neaps or "dodging" tide, the pointer does not move much either up or down, and the time



A Tide-Predicting Machine.

By Captain A. INGLIS.

of high or low water uncertain, the vertical slide can be put in and the curve traced, the time and height can then be measured off.

When one of the carriers (of which there are three) is through the frame it can be disconnected from the others and connected up again at the other end, the curves are again placed in their respective grooves, butting close up to the preceding ones, and so on, forming a continuous chain of curves. With a little practice this can be done expeditiously, and very little time lost.

By means of this machine the tides for a year can be predicted, and a tide-table published at a comparatively small cost, because the time and height can be read off and tabulated at once ready for the printer.

In other tide-predicting machines where the motion of each component is represented by an eccentric or crank and pinion, it is necessary to drive each wheel at a different speed, and this necessitates very complicated gearing. In this machine, however, all the components are driven along at the same speed, and the machine is thereby greatly simplified. No matter how irregularly the handle is turned the motion forward automatically indicates the time.

The machine has been tested by setting it for a year that was past, and the results compared with actuality. This comparison showed that there was a probable error of from five to ten minutes in time, and from 6 to 8 inches in height, which may be considered very good for a place where the meteorological effects bears such a large proportion to the ordinary rise and fall.

No. 6.—THE TIDES OF SOUTH AUSTRALIA.

By R. W. Chapman, M.A., B.C.E., and Capt. A. Inglis.

(*Read January* 10, 1898).

At the Adelaide meeting of the Association, we stated that we were then engaged in making a second analysis of the Port Adelaide tide curves. The work was soon afterwards completed, and the results of the second analysis are stated in the following table, side by side with the first ones. We found, however, that through too blindly following certain wrong instructions in "Baird's Tide Manual," that we had made an error of 180° in

several of the phases in the first analysis, and we now give the corrected results. They are stated in terms of the notation adopted in the British Association reports. The larger components show a very fair agreement in the two cases, but, as is to be expected, the smaller ones do not agree so well. This has been found to be the case at other places where the tides have been analysed, notably in India; the amplitudes being so small they are confused with the meteorological effects.

Results of Harmonic Analysis of Port Adelaide Tides.

	Analysis of Tide Curve for 12 months beginning midnight, February 28, 1889.		Analysis of Tide Curve for 12 months beginning noon, January 1, 1893.	
	Semi-range in feet.	κ	Semi-range in feet.	κ
S_1	·08	122°	·06	108°
S_2	1·66	180°	1·70	182°
S_4	·02	178°	·04	194°
S_6	....	....	·01	180°
P	·21	51°	·22	62°
K_1	·84	51°	·82	54°
T	....	....	·11	165°
R	....	....	·04	138°
K_2	·47	177°	·46	179°
M_1	·01	24°	·03	8°
M_2	1·71	121°	1·69	119°
M_3	....	....	·06	99°
M_4	·02	176°	·02	171°
M_6	....	....	·01	259°
N	·08	294°	·10	198°
L	....	....	·12	140°
ν	....	....	·06	76°
O	·53	34°	·51	30°
J	....	....	·05	65°
Q	....	....	·07	31°
μ	....	....	·28	226°
2 SM	....	....	·10	67°
MS	....	....	·09	99°
Sa	·25	132°	·36	121°
Ssa	·17	123°	·28	54°
MSf	·13	256°	·11	254°
Mf	·08	194°	·04	168°
Mm	·08	258°	·06	143°

The behaviour of a wave in travelling up a gradually narrowing channel is well exhibited in the tidal effects of Spencer and St. Vincent Gulfs. The wave is propagated with a greater speed along the deep water of the middle of the gulf than along the

shallows at the sides, so that it is everywhere high water in the middle of the gulf some considerable time (about one and a quarter hour opposite the Semaphore) before it is high water at the opposite points on the shore at each side. By the time the wave has reached the head of St. Vincent Gulf, the co-tidal line is practically parallel with the coast line for some considerable distance all round, so that the wave reaches Port Wakefield, at the head of the gulf, at the same time as it reaches the Semaphore and Black Point at the sides, and the time of high water is the same at the three places. Further, as the wave travels up the gradually narrowing gulf into shallower water, its speed diminishes but its height increases; so that the mean spring range of the water is 6 ft. at Rapid Head, 8 ft. 3 in. at Port Adelaide, whilst at the head of the gulf at Port Wakefield the range is 11 ft. Again, going up Spencer Gulf the spring range is 5 ft. at Thistle Island, but becomes increased to 12 ft. at Port Augusta. The tide enters St. Vincent Gulf by the two channels round Kangaroo Island, but unfortunately observations have not been taken at a sufficient number of points round the island to enable us to trace out the co-tidal lines. It is peculiar that high water reaches Ante-Chamber Bay one and three-quarter hour before it reaches Cape Willoughby. Apparently when the tide enters the gulf there is a strong current setting across from Sturt Bay on the peninsula, to Hog Bay on the island, as has been evidenced on several occasions by the way in which wreckage has been carried.

A peculiar tidal phenomenon takes place at Port Lincoln, which was noticed by Flinders. He observed there that "the tide did not exceed 3½ feet, and that, as in Princess Royal Harbour, there was only one high water in twenty-four hours, which took place at night, about eleven hours after the moon's passage over the meridian. Yet at Thorny Passage, which is but a few leagues distant, there were two sets daily. This difference in so short a space appears extraordinary; but it may perhaps be accounted for by the direction of the entrance to the port, which is open to the N.E., from whence the ebb comes."* The suggestion here made by Flinders gives us the explanation of the phenomenon, when we take into account as well the diurnal inequality. Thus at Port Lincoln, the observable tide is really the higher one of the two daily tides. Owing to the direction of the outlet of the harbour the water cannot get out freely, as the harbour catches the ebbing tide from the gulf, with the result that the level of the water falls very slowly; so slowly in fact, that the second lower tide which follows in the course of the day does not appreciably raise the level of the

Captain Flinders, Terr, Aust., Vol. I, p. 150.

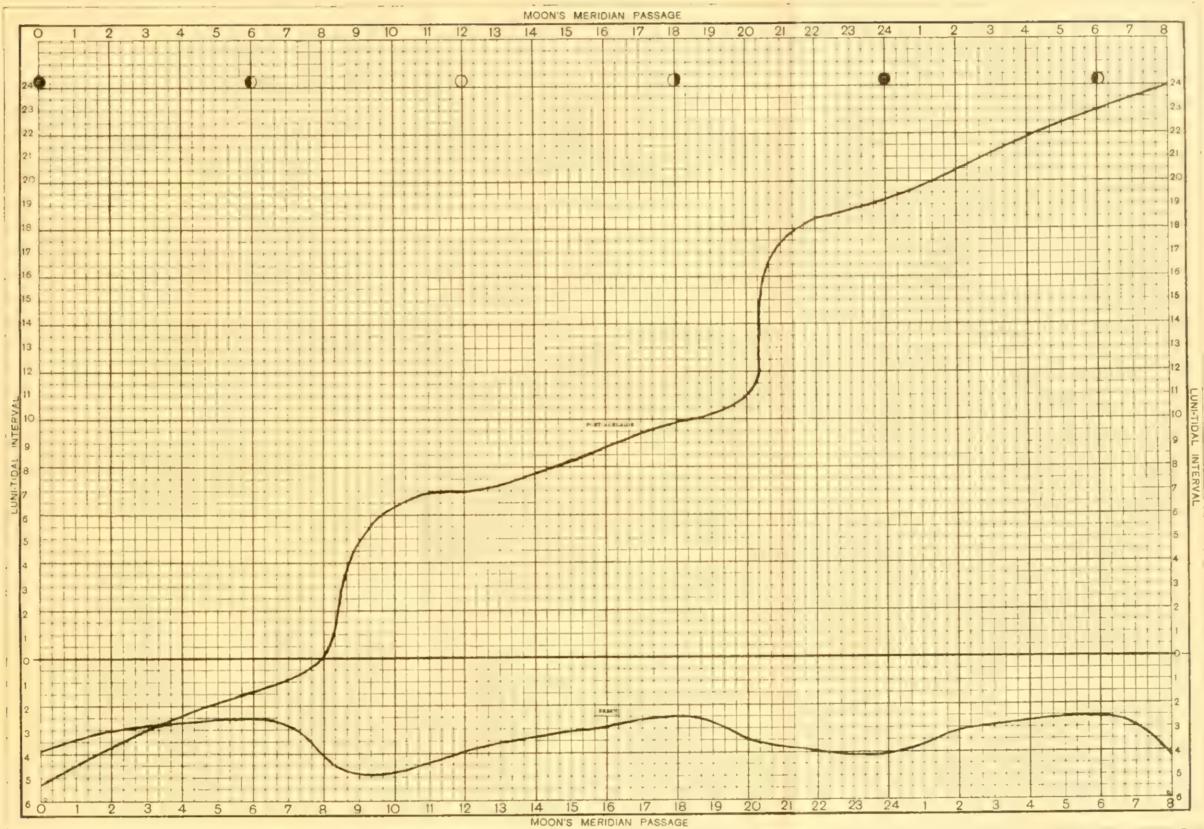
water, and so is not apparent as a tide. At Boston Bay there are two tides with a large diurnal inequality so marked as to make it sometimes appear that there is only one tide in the day.

The absence at these ports of that intimate connection between the time of high water and the time of the moon's passage across the meridian, which is so marked in the ports of the North Atlantic, is well brought out in the accompanying diagram. In this we have plotted curves, for Brest and for Port Adelaide, showing the nature of the changes in the interval between the moon's meridian passage and high water on successive days at these ports. The ordinates to the curve are drawn at equal distances apart for successive tides, the length of the ordinate representing the interval. The lower curve represents the result in the case of Brest, and shows a regular wave lying wholly on one side of the zero line. When, however, we attempt to do the same thing with our Port Adelaide tides we find that instead of getting a periodic curve the interval shows a continuous progression, as is exhibited on the same diagram by the upper curve. In fact we have not the same number of tides in a month as there are transits of the moon.

No. 7.—NOTES ON THE VERTICAL COMPONENT OF THE MOTION OF THE EARTH'S ATMOSPHERE, AND A WIND-VANE, SHOWING VERTICAI MOTIONS OF THE AIR.

By Major-General Schaw, C.B.

(Read January 10, 1898.)



The Tides of South Australia.

R. W. CHAPMAN and Captain INGLIS.

No. 8.—EXPERIMENTS ON SOME ELECTRICAL PROPERTIES OF PURIFIED SULPHUR.

By PROFESSOR THRELFALL, M.A., and J. BERNARD ALLEN, B.SC.

(Read January 10, 1898.*)*

NOTE.—The experiments described in this paper form part of a more elaborate investigation. Other results of the investigation have already been published "The Electrical Properties of Pure Sulphur," Threlfall and Brearley, Phil. Trans. Vol. 187 (1896) A. In that paper many matters, here merely referred to, are fully dealt with, *e.g.*, the methods of purifying the sulphur. Quantitative results are given for the conductivity of sulphur under various conditions of solubility. Section III of this paper deals with the general character of sulphur conductivity when the sulphur is much less soluble. The general bearings of this section will be plainer if read in connection with the paper above referred to.

SECTION I.—CONTACT FORCE BETWEEN DIFFERENT KINDS OF SULPHUR.

IT has been shown that when two metals are in electrical contact a difference of potential exists between them. The same thing has also been found to be true of different non-conductors. It seemed probable, therefore, that a similar difference of potential might occur between the same substance in different molecular conditions. The following experiments were undertaken with a view to determine whether any such voltage could be detected between sulphur in the soluble and insoluble states.

As a first method an electrometer needle was made of sulphur, half of it being soluble, and the other half insoluble. This was hung within the quadrants of an electrometer, which were joined in adjacent pairs, so as to be virtually semicircles at different potentials. If, then, one end of the needle were at a higher potential than the other, a deflection would be produced reversing in direction upon interchanging the potentials of the semicircles. As an alternative method sulphur quadrants were made, alternate quadrants being formed of the soluble and insoluble modifications. Above these was hung an ordinary electrometer needle. If any voltage existed between the quadrants the needle would be deflected from its position of equilibrium upon charging it.

The principal obvious source of error to be guarded against was the disturbing effect of ordinary electrostatic induction. The electrometer used was of the Clifton pattern. The case was lined with tinfoil, except at the front and back, which were of glass. Cardboard shutters covered with tinfoil were made to cover these

places, so that the inside could be perfectly screened from external action. No difference of effect was at any time noticed upon removing or replacing these shutters, so that the screening from outside effects must have been sufficiently perfect.

The induction from the charged parts of the apparatus upon the sulphur regarded as a conductor was shown in the course of the experiments to have considerable effect, the conductor induction upon the insoluble parts being greater than upon the soluble, as their conductivity is greater. This source of error was guarded against in using the sulphur quadrants, as will be explained later, but in using the sulphur needle the disturbing effect was considerable. For if the semicircles were electrified oppositely, the insoluble end of the needle would have its halves oppositely charged by induction, the corresponding effect upon the soluble end being much weaker, owing to difference of specific resistance and specific inductive capacity, as has been stated. The effect of induction would therefore be to subject the insoluble end of the needle to two pulls in opposite directions. Any want of symmetry might cause one of these pulls to be greater than the other, and so a deflection might be produced due to induction alone. The reversibility of such an effect would depend largely upon the rapidity with which induction charges could distribute themselves on the needle, and other things that cannot be determined. As it is impossible to ensure perfect symmetry, some error is sure to occur due to this cause; accordingly the results obtained with the needle were unsatisfactory. Upon hanging the ordinary needle in position and charging the quadrants, connected as described, deflections of over 40° were obtained by induction effects, but as the needle was connected with the condenser, the case hardly corresponded to that of the sulphur needle. The needles were cast in an aluminium mould. To make this two pieces of aluminium plate 1 mm. in thickness were taken. From one of these a piece was cut out resembling in shape half of an electrometer needle. This plate was then sawn across so that it could be removed from the sulphur in two pieces. The two plates were then clamped together.

In order to obtain the soluble half of the needle the mould was heated gradually on a brass plate with a gas flame till particles of sulphur dropped on it began to melt. The flame was then removed and sufficient sulphur placed in the mould to fill it to the level of the second plate. After the sulphur was melted and cooled the pieces of the upper plate were carefully removed. In order to remove the sulphur needle from the second plate, the latter was heated very gradually until the sulphur could just be pushed off by means of a glass rod. The half needle thus obtained was heated for some time in an air bath to a temperature of 108° C. and then allowed to cool very slowly.

To obtain the insoluble half the mould was prepared just as before, the sulphur melted as in the previous case, but the temperature was raised till the sulphur became thick and dark. It was then suddenly quenched in water, left in the mould for about half an hour till it became stiff enough for removal, and taken off with a sharp knife.

The two halves of the needle were cemented together with sulphur by means of a piece of hot aluminium. A fine fused quartz-rod was fastened to the centre; to this was attached a mirror, and the upper end was bent into the form of a hook. This could be hung on to a glass hook suspended bifilarly above the quadrants with silk, so that the needle could easily and quickly be removed and replaced.

To make the sulphur quadrants a shallow zinc dish was prepared, with a round hole at the centre, through which the wire from the needle was allowed to pass. Four zinc partitions were fitted in, dividing the dish into quadrants. The dish was heated and two opposite quadrants filled with sulphur, the temperature was raised till the sulphur was on the point of burning, when the whole was cooled by plunging into water or laying the dish upon a block of ice. The partitions were removed, and the other quadrants were filled with soluble sulphur. This sulphur was first annealed and then heated to the melting point, care being taken not to heat it much above 128° C.

The sulphur had to be freed from any free electrification due to rubbing, or any cause other than contact difference of potential. This was done by passing a flame over it several times. It was rather difficult to do this with the needles without cracking them or setting them on fire, so that no very complete series of results could be obtained with the same needle.

The needle was first diselectrified and hung inside the quadrants. Upon connecting one (adjacent) pair with the case and earth and bringing the other pair to a positive potential of about 50 volts by means of a storage battery there was a deflection of the soluble end towards the charged pair of quadrants. When the electrification was transferred to the other pair of quadrants the deflection was reversed, that is to say, the soluble end was still attracted towards the charged pair.

The deflection obtained in this way was very small, not more than two or three divisions on the scale, placed 1 metre away. To increase the deflection an electrophorus was used; the results were exactly similar but much larger. The needle was hung above the quadrants, but the effects were not altered. In making further alterations the needle broke.

The experiment was repeated with a new needle, but this time exactly opposite results were obtained. The soluble end being deflected towards the uncharged pair of quadrants. The effect

appeared to be reversible, but upon trying repeatedly the deflection became less regular, so that the deflection in one direction was greater than that in the other. On leaving the apparatus for an hour or two without disturbance and then repeating the experiment a deflection was obtained which would not reverse on reversing the electrification of the quadrants. These experiments with the needles showed that if there were any contact effect constant in character the imperfections of the needle method were such that it could not be satisfactorily established in this way.

The experiments with the quadrants were much more satisfactory and consistent. For the first two sets of quadrants ordinary roll sulphur was used. The first set was made in a dish 11 cm. in diameter, the second was 11·5 cm. in diameter.

The zinc dish containing the quadrants was first of all placed upon the brass quadrants of the instrument and the aluminium needle hung immediately over them. The needle was charged, as in the ordinary use of the instrument, through the sulphuric acid of the condenser.

For the first few trials no very consistent results were obtained owing, as it afterwards appeared, to insufficient diselectrification. Using first a potential of 50 volts a small deflection towards the insoluble quadrants was noticed when the charge on the needle was positive and towards the soluble when the charge was negative, but the deflection towards the insoluble was always much smaller than that towards the soluble. On rotating the quadrants through an angle of 90° the deflection was reversed.

The zinc dish was insulated from the brass quadrants on mica plates, and the potential used raised to 100 volts. In this case the deflection could not be reversed by changing the sign of the charge. The deflection was always towards the soluble quadrants, being larger in one direction than the other. These results showed that some disturbing influence was at work, so the quadrants were taken off and thoroughly diselectrified.

Upon replacing them the electrophorus was used to charge the needle. The deflection was then much larger: the spot could easily be sent completely off the scale. The displacement was now invariably towards the soluble quadrants, the charge being positive. The quadrants were rotated repeatedly through 90° each time, and every time the deflection was reversed. The reversal showed that the deflection could not be due to induction or other effects between the needle, case, and brass quadrants, as the only part moved was the sulphur dish. The deflection must have been due to something in the sulphur. The case was sometimes insulated and sometimes joined to earth. The quadrants also were sometimes insulated on mica, but no alteration of the effect was noticed; the needle was always attracted towards the

soluble quadrants and repelled from the insoluble, the needle being charged positively.

The second set of quadrants was then made, and the same series of experiments was gone through. The quadrants were diselectrified as usual and placed in position. Exactly the same results were obtained as with the first set after diselectrification. The electrophorus was first used for charging. There was a large deflection towards the soluble quadrants. On rotating through 90° the deflection was reversed, still towards the soluble quadrants. The rotation was performed repeatedly without any contradictory result being obtained. The insulation of the case and brass quadrants was altered without alteration of the result. The battery being used to charge the needle a positive charge gave a deflection in the same direction as before; a negative charge turned the needle towards the insoluble quadrants.

One of the insoluble quadrants was rubbed a little with a bit of flannel, and the deflection on charging with the electrophorus was reversed, turning towards the insoluble quadrants, and showing that sufficient negative electricity is easily developed on the insoluble sulphur, to overcome that on the soluble, due to contact effect. This reversal of effect ceased after about fifteen minutes.

At one time, with these quadrants, we noticed a reversal of the direction of deflection upon greatly increasing the charge; but this was much better seen, and further studied, with the third set of quadrants.

The third set of quadrants was made in the same dish that was used for the second, but greater care was taken in their manufacture. Instead of roll sulphur pure Chance Claus sulphur once distilled was used. Much greater care was taken to ensure perfect solubility in the soluble quadrants. The sulphur used for them was very gradually heated to about 116° C. in an oil-bath, several hours being consumed in the process. The sulphur was left for some time at this temperature, and then slowly cooled. This process was repeated a second time. In order to melt it, it was heated in the oil-bath again to 128° C., and then poured into the zinc dish. In order to obtain a smooth even surface, and to distribute the sulphur over the quadrants, the surface had to be smoothed by a piece of aluminium heated till particles of sulphur would just melt on it.

Besides the diselectrification as before, this set was diselectrified *in situ* by means of a fine gas jet. In order to prevent the possible electrifying effect of rubbing when rotating the zinc dish upon some other substance, a zinc plate, cut from the same piece as that from which the dish was made, was placed beneath it, and to vary the tests of reversibility, two mirrors, at right angles, were fixed on to the needle-rod, so that the needle could be rotated as well as the quadrants and its deflections observed.

The electrophorus was used to charge the needle. Upon a charge being given, there was a deflection towards the soluble quadrants, as there had been before. On increasing the charge, the deflection increased to the extent of about 123 divisions on the scale. Still increasing the charge, the deflection began to decrease, till at last the spot of light stood again at zero. Still increasing the charge the deflection reached 130 divisions on the other side of zero. On allowing the charge to gradually dissipate, a reverse series of movements was gone through; the deflection towards the insoluble quadrants disappeared and changed back to the original direction. When it reached eighty-five divisions in this direction it again altered the direction of movement and gradually settled down to zero.

The needle was then rotated through 90°, everything else remaining as before. On charging (positively) there was a large deflection as before towards the soluble quadrants. When the charge was increased, the deflection diminished again, and then a deflection towards the insoluble quadrants took place, which was increased to about 20° by sufficiently increasing the charge. On allowing the charge to leak away, the effects were gone through backwards just as before. Rotating the needle several times the same results were obtained.

This reversal effect upon increasing the positive charge on the needle could be accounted for by induction in the insoluble quadrants. Insoluble sulphur has a higher specific inductive capacity, and certainly a much higher electric conductivity than the soluble modification. Surface charge, due to difference of specific inductive capacity of sulphur from that of air, would, therefore, be greater on the insoluble quadrants. Induction charges, such as those formed in the ordinary way upon conductors, would also be much more rapidly formed on the insoluble sulphur; they would also leak away more quickly.

Starting, then, with a negative charge on the soluble quadrants, and a positive on the insoluble, due to the contact of the two modifications, the deflection on giving the needle a positive charge would be towards the soluble sulphur as usual. On increasing the charge, the induced charge would begin to have effect. The positive charge on the needle would induce a negative charge on the upper surface of the insoluble quadrants, which would tend to reverse the deflection, and when this induced charge became sufficiently great would actually cause a reversal. On allowing the charge to leak away, the induction charge would disappear, and so the deflection would return to its original direction, but would not attain its first maximum owing to the diminishing charge on the needle.

To test whether this was the true explanation, it was considered that, if the needle were charged negatively, no such

reversal should take place, as the direction would originally be in the direction of the insoluble quadrants, and the induction charge would tend the same way. To obtain a sufficiently great negative charge, a small Wimshurst machine was used, with results that had been anticipated. The deflection was towards the insoluble quadrants, increasing with increasing charge, but no reversal of the direction could be obtained.

The charging was repeated with rotation of the needle and of the quadrants in all possible positions, but with the same effect each time—deflection towards the insoluble with a negative charge, and to the soluble with a positive charge, the latter of which reversed in direction upon sufficiently increasing the charge.

Care had to be taken that the needle was well discharged before every charging, as it was found that the residual charge of the jar was sometimes sufficient when the needle had been imperfectly discharged to re-charge it beyond the position of reversal.

The general conclusion arrived at, therefore, was that there is a difference of potential set up upon contact between soluble and insoluble sulphur, the positive charge being on the insoluble, and the negative on the soluble. This conclusion was always consistent with the results obtained with the sulphur quadrants when care was taken to diselectrify them. All possible induction effects were either eliminated by reversal or accounted for in the phenomena observed. Although no consistent results were given with the sulphur needles, it has been shown that this may easily be due to the inherent defects of the method, and not to any uncertainty as to the contact voltage under consideration.

It was not possible by this method to measure the difference of potential obtained. As the proportion of insoluble sulphur in the so-called insoluble quadrants is a very variable quantity, decreasing slightly with a lapse of time, the voltage probably varies largely also, so that a particular result would not have any general applicability. To get an idea, however, of the voltage noted, a Leclanché cell was used with the brass quadrants; and it was found that on charging the needle as before, deflections were obtained not differing very widely from those given with the sulphur quadrants. It is, therefore, probable that the voltage developed between soluble and ordinarily insoluble sulphur amount to something of the order of one volt.

The so-called insoluble sulphur is really a mixture of about 5 per cent. of insoluble with 95 per cent. of soluble sulphur, the latter being at first mostly prismatic and afterwards mostly octahedral. As no difference of effect was observed after several days ageing of the quadrants, we may consider that the above results are not dependent on the particular crystalline condition of the soluble sulphur.

SECTION II.—ACTION OF LIGHT ON THE CONDUCTIVITY OF SULPHUR.

The action of light in reducing the resistance of selenium is well known. Dr. Monckman (Phil. Proc., 1889) considers that he has observed a similar effect with sulphur, but the observations chronicled by him leave considerable doubt on the question. Of his three sets of observations, the first points to a considerably reduced resistance in the light; the second and third to a slight increase of resistance. The conductivity varies considerably from time to time. Dr. Monckman's experiments can hardly, therefore, be considered conclusive, even assuming the purity of his material.

Some experiments have been made by us to determine whether light really has any appreciable effect upon the conductivity of sulphur.

The first question to be considered was as to what molecular modification should be used. Sulphur, in the soluble state, is at the present limit of experimental method practically a perfect non-conductor. Pure insoluble sulphur on the other hand cannot be obtained in a film suitable for experiment. The only course was, therefore, to use a mixture of soluble and insoluble sulphur, for which some small conductivity has been proved. This being so, it was obviously desirable to obtain the sulphur in the state of greatest conductivity, and to this end the sulphur was prepared with as great a proportion of insoluble sulphur as possible.* Analyses made with two cells used, gave 21·35 and 14·96 as the percentages of insoluble sulphur. The composition of the other cells was probably within these limits. As regards quality, the cells were made from roll sulphur twice distilled, one or two, however, being made from sulphur that had only been once distilled.

Various experiments were made to determine what form of sulphur resistance cell was most suitable, the following form being finally adopted. A rectangular slab of sulphur was taken, about 6 cm. long by 3 cm. broad, and from 3 to 4 mm. thick. This was wound with two parallel spirals of thin platinum wire, which were nowhere allowed to touch, but were wound as closely as possible, the average distance between the spirals being a little over 1 millimetre for most of the cells. After winding, a hot glass rod was passed over the wire, which was thus pressed into and covered with a thin film of sulphur. A large conducting surface of sulphur is obtained in this way, which can easily be exposed to light.

* It was thought at this time that the conductivity would be found to increase with the proportion of insoluble sulphur present.

The sulphur slabs were cast in little zinc moulds. These were filled with sulphur, and heated till the sulphur was on the point of bursting into flame; they were then plunged into cold water. When the sulphur was sufficiently set, the dishes were cut off with a knife. When quite hard, they were scraped carefully all over to remove any surface contamination which might have been caused by exposure during heating or by immersion in the water. They were dried by warming and leaving some hours over phosphorus pentoxide. The weakest part of this method for the preparation of the cells is undoubtedly the melting in of the wires by means of hot glass, for it is difficult to ensure that the rod shall be perfectly clean, and the annealing produced is quite uncertain.

At first the electrometer method was used to measure the resistance of the cells, but no very satisfactory evidence was obtained in this way. When a steady fall of electrometer deflection was observed on short-circuiting the electrodes through the sulphur, no constant difference in the rate of discharge was detected on exposing the sulphur to light. Both sunlight, gaslight, and magnesium light were used, but with entirely negative results. These results were affected by the imperfect shielding of the sulphur from dusty air.

Most of the experiments were made by the galvanometric method. The cells were hung by means of the ends of the platinum wires in jars containing phosphorus pentoxide to ensure dryness, the wires passing through small holes in the lids of the jars. The battery and galvanometer were connected in simple series with the cell. The battery consisted of forty Clark cells.

It was invariably found that when first the circuit was completed there was great irregularity of conduction, and it was only after some time—a time which varied from about an hour with some cells to as much as a day with others—that a deflection could be obtained sufficiently steady for the experiments to be tried.

Remarkable changes in the conductivity were observed. As regards the action of the light, however, the method of procedure was very simple. A steady deflection having been obtained in a darkened room, a piece of magnesium wire was lighted, so as to shine on the sulphur cell. Any change in the conductivity should have been accompanied by a change in the deflection. None was in any case observed. Owing to changes of zero of the galvanometer, an apparent change of deflection to the extent of one or two divisions was sometimes noticed, but after repeated trials this change was found to be just as often in the direction of a decreased deflection as of an increased one. During numerous trials, however, when the galvanometer was exceptionally steady, perfectly steady deflections were obtained, both before and after

the light was applied. In these cases no change of deflection was ever noticed.

The voltage used was varied from that given by one Clark cell to that of forty cells, acccording to the conductivity. The deflections varied from 30 to over 150 mm., and as a variation of a couple of divisions could be certainly measured, the experiments show that, with sulphur in the form in which we have used it, light cannot affect the conductivity to the extent of more than 1 per cent.

SECTION III.—CONDUCTION IN SULPHUR OF HIGH INSOLUBILITY.

As has been already stated in experimenting upon the effect of light upon the conductivity of sulphur, all the ordinary phenomena of sulphur conduction were obtained, some of them in an apparently exaggerated form. As considerable insolubility was obtained in these experiments, the method used appeared well adapted for extending the qualitative results obtained for the electric conductivity of sulphur of large solubility to sulphur of much less solubility.

The form of sulphur conductor was, of course, made in the first instance with a view to obtain as much conductivity as possible in a sulphur cell that could be exposed to light without difficulty. Various methods of winding platinum upon mica, &c., and covering with sulphur were tried, in imitation of the cells made by Adams, Bidwell, and others in the study of selenium. These cells were finally rejected in favour of cells made in the way already described, which were used throughout in the experiments with light.

On account of the possibility of contamination, however, the results given by the cells made in the fashion described cannot be relied upon as accurate. The general character of the phenomena observed may, however, be given.

The different cells made differed widely in conductivity, with some of them a single cell was sufficient to send the light spot the whole length of the scale, while with others the whole battery of forty cells was used, and the deflection then obtained was small.

The following facts appeared to be true of all the cells :—

1. The deflection which was obtained when the current was first passed gradually diminished all the time the current was running.
2. After this decrease of conductivity, if the direction of the current through the sulphur was reversed, the deflection was increased considerably.
3. When the number of cells in the battery was increased the conductivity increased, some minutes elapsing generally before the maximum current was obtained. The deflection then began to decrease again as usual.

With most of the cells, but not all, the conduction obtained exhibited the peculiar jumpy action before observed with sulphur. When a steady deflection appeared to have been attained it would suddenly increase to, perhaps, double its value, returning again almost immediately to its former value.

In one case a cell that was being studied as it hung in undried air gave this jumpy action, but when the air was dried with phosphorus pentoxide no conductivity at all was obtained. It appears, therefore, that this peculiar action may be sometimes due to a surface conductivity, and is not perfectly characteristic of sulphur.

The higher conductivity in one direction than the other at once suggests the presence of an E.M.F. in the sulphur itself, and of sufficient magnitude to give a current observable through the galvanometer. With the first four cells no deflection could be detected upon shortcircuiting the sulphur cell through the galvanometer. Cell No. 5, which showed the relation between conductivity and direction very markedly, the deflection in one case being 30 in one direction and 560 in the other, gave a deflection of two divisions on shortcircuiting through the galvanometer. Two more cells were then made as much alike as possible with a view to determine to what extent time alone was responsible for the changes of conductivity, and how much was due to the passage of a current. In studying these cells, which had a much higher conductivity than any of the others, the resistance being originally 6·2 and 7·4 megohms, it was found that they exhibited a considerable back E.M.F. giving large deflections with the galvanometer. This contrast of properties with those previously made was another indication that the method was uncertain.

On testing these cells with the quadrant electrometer they were found to give a deflection of from thirty to thirty-five divisions, *i.e.*, about 1 volt. This was the same whether the five cells or forty were used to produce the voltage and was not increased by leaving the battery on for a lengthened period, indicating that the polarisation was galvanic and not dielectric residual. The direction of the voltage in the cell was reversible by leaving the battery in series with it for about half a minute.

In order to get rid of some of the objections to this method of manufacture a cell was made in the same way as regards winding, &c., but instead of touching with hot glass the cell was dipped as rapidly as possible into a bath of sulphur heated till it was as thick as it was practicable to make it, so as not to melt the sulphur slab in the process of immersion. The wires were thus covered with sulphur, but the insolubility obtained in this way was not so perfect as by the first method. A deflection of

eighteen divisions was obtained with this cell using a 40-cell Clark battery, but the deflection rapidly decreased to zero, and after that no conductivity could be detected.

In order to combine the advantages of the two methods, *i.e.*, to have great insolubility and pure uncontaminated sulphur the following method of manufacture was finally used for the sulphur cell.

Two glass rods 7·7 cm. long and ·45 cm. in diameter were fixed parallel to one another, and with their centres 3 cm. apart by means of two aluminium cross bars, through which the glass rods passed. The length of the glass rods between the aluminium bars was 6·2 cm., forming a sort of Oxford frame upon which to wind the platinum wire. Each electrode was formed of twenty complete turns of platinum wire wound upon this frame, the total length of wire to each electrode being 160 cm. There were, therefore, altogether forty complete turns at an average distance of 1·5 mm. from one another. After the frame had been very carefully cleaned the wire was wound on, the electrodes being joined, one to each aluminium bar. The frame was provided with an aluminium handle about 6 cm. long.

The sulphur used for this cell was once distilled Chance sulphur. This was heated to melting, and the frame immersed in it. The temperature was then raised till the sulphur was so thick that on withdrawing the frame the latter was covered thickly all over with a mass of viscid sulphur. It was then suddenly immersed in distilled water and left till cold. In this way the whole frame was covered with highly insoluble sulphur, the electrodes being shielded from surface action by a thick coat of sulphur. The conductivity of this cell was small in comparison with that given by some of the cells obtained in the other way, another indication that some at least of the cells had been spoilt by the glass-rod process of burying the wires, for some of them were made with pure sulphur.

The cell was first tested for polarisation by the quadrant electrometer. No certain positive effect could be observed, though owing to the residual charges in the keys necessarily used, no very satisfactory experiments could be made.

For the galvanometric study of the cell it was hung by means of its electrodes in the thermostat.

With forty cells the elongation upon reversing the current through the galvanometer was fourteen divisions. This elongation fell regularly in half an hour to five divisions, the temperature being 25·5°.

The oil-bath was then heated, the galvanometer throw every few minutes being taken while the temperature was rising.

The following table is sufficient to show the variation of conductivity during heating :—

Time. h. m.	Temperature.	Elongation on reversing through galvanometer.
11·32	25·5	14
11·40	25·5	10
12·0	25·5	5
12·6	26	5
12·12	27·5	7
12·22	33·25	31
12·33	40	35
12·37	42	32
12·45	46	20
12·55	50	14
1·0	54	9
1·12	62·5	6
1·26	73·5	3
1·33	77·25	2
2·18	91	2
2·44	101·5	4
2·57	101	12
3·1	100	9
3·23	102	12
3·27	103·25	17
3·31	105·25	23
3·35	106·5	41
3·40	107·5	77
3·43	109	156
3·48	110	377
3·58	105	Off scale.
		Elongation on stopping the current.
4·8	103·5	620
4·12	103	606
4·18	102·75	634
4·28	102·25	548
4·45	102	389
		Reversing as at first
5·0	101·8	526
5·33	101·5	315
6·17	100	112

The cell was left to cool slowly.

The deflections obtained were steady; at no time were sudden variations observed comparable with the jumps observed before with sulphur conduction.

The table given shows that there was only a small change of conductivity upon increase of temperature until the temperature

was raised above 100°. While the annealing process was going on there was an immense increase of conductivity. This might be due either to the fact that the annealing was going on, or else merely to the fact of the sulphur being at the high temperature in question.

In order to determine between these alternatives the cell was again heated in the same manner as before and the galvanometer kicks noticed.

At the temperature of the room no deflection at all could be detected, the sulphur being probably almost completely soluble.

On heating, none of the former changes of conductivity could be noticed. At 57·5° C. the kick, or reversal, was 2 divisions, and the reading the same very nearly all the time the cell was being heated up to 110°, and after it started to cool again. The elongations varied slightly between 1 and 3; but on account of the smallness of the deflections, and the small movements of zero, the variations may have been due to errors of reading as much as to variation of the properties of the sulphur. They may also have been caused by the intermittent conduction frequently shown by sulphur.

No series of changes was gone through on this second heating such as upon the first heating, showing that the great increase of conductivity above 100° at the first heating was not due to the temperature alone, but was due either to the fact that the process of annealing and the change from insoluble to soluble sulphur was actively going on, or to the fact that insoluble sulphur possesses the power of conduction when mixed with the soluble variety. The experiment, as a test of whether the progress of the change from insoluble to soluble was the real cause of the conductivity, remains indecisive.

After again cooling, no current whatever could be detected through the sulphur.

On testing its solubility, it was found that there was only a trace of insoluble sulphur present.

An analysis of a piece of sulphur broken from the cell previous to annealing gave as the composition 19·68 per cent. of insoluble sulphur. Of the cells made by the first method two were analysed, giving as their composition 15·69 and 21·35 per cent of insoluble.

Though the sulphur was considerably cracked after the first annealing, it is probable that the separation of the sulphur from the wires was not sufficient to account for the total change of conductivity.

No. 9.—RESULTS FROM VARIOUS-SIZED RAIN-GAUGES.

By H. C. Kiddle, F.R.M.S.

(*Read January* 11, 1898.)

No. 10.—CLOUD OBSERVATIONS IN VICTORIA.

By P. Baracchi, F.R.A.S., Government Astronomer, Melbourne.

(*Read January* 11, 1898.)

The year 1897 has been called by some writers on Meteorological subjects "The Cloud Year," on account of the systematic observations of clouds which were carried on in nearly all the civilised countries during that period, under a scheme laid out and finally agreed upon, in all its detail, by the International Meteorological Committee at its Upsala meeting in 1894. The object of the scheme was to obtain more uniform and comprehensive data, to serve as the basis for the furthur study of atmospheric conditions, as indicated by the forms and movements of clouds.

All the Central Meteorological Institutions were asked to co operate, and some of the Australian colonies promised to contribute their share. The operations contemplated in the scheme were of two distinct classes :—

1st. Observations of form, direction of motion, and apparent velocity of clouds, to be made three times daily, when possible, by as many observers as could be recruited by each institution ; the observations to be made without instruments, or with the simple nephoscope.

2nd. Observations for the determination of the absolute height and velocity of clouds, made with instruments of precision, either visual or photographic.

It was further intimated that the operations were to commence on May 1, 1896, and to be continued for twelve months; but the period was afterwards altered from January 1 to December 31, 1897, owing to various countries being unable to commence at the earlier date.

The fixed period was more particularly intended for the observations of the 1st class, and more latitude was given for the absolute measurements.

In Victoria we have just concluded the first part of the work, and the second part is still going on, and will probably be continued for some time longer, as the past experience has taught us that it can be further improved.

It is not my purpose to discuss the complex problems for the treatment of which the cloud scheme was initiated, nor to speculate on the possible advantages which many authorities expect to derive from it for the advancement of meteorology, practical and theoretical. I shall merely give a brief sketch of what has been done in Victoria.

In order to secure observations of the first-class (non-instrumental) at various up-country places, a circular was issued towards the end of 1895 inviting volunteer observers to join in the work, and fifty-one names were enlisted. After preliminary instructions and practice, the work commenced on May 1, 1896, in accordance with the original resolutions of the I.M.C.

On examining the returns of the first three months it was found that a little more than one-third of the observations were not sufficiently reliable, and the number of observers was reduced to about thirty. Some of these continued their work till May, 1897, but only eighteen could be induced to extend their services to the end of the year; so that for the cloud year proper we have only the complete returns of eighteen observers, whose work is regarded as being entirely satisfactory throughout.

The work of the other twelve observers, however, will be duly utilised.

The returns contain records of observations made three times daily whenever practicable, and give for each observation:—

1st. The form of the cloud, in accordance with the classification of the I.M.C., and identified by means of the official cloud atlas.
2nd. The approximate position in azimuth and altitude.
3rd. The direction of motion within one point of the compass.
4th. The apparent velocity. This was estimated in terms of a scale of 5, based on the time occupied by a selected point in the cloud to move through an arc of 15°.
5th. Special notes on cirrus clouds, the direction of cirrus bands, the position of their vanishing points, &c.
6th. Direction and force of the surface wind, temperature of air, weather characteristics, and general remarks.

There are some 20,000 such observations now ready for discussion; but as they were concluded only a few days ago, there has not been, nor will there be for some time, any opportunity of arranging this great mass of records in proper form for the deduction of results and publication *in extenso* as requested by the committee.

For the second part of the work, namely, the determination of absolute height and velocity, a pair of stations for simultaneous observations were established, one being on the grounds of the Melbourne Observatory, and the other on the roof of Parliament House, at a distance of 6,820 feet, bearing N. 3° 38′ 51″ W.

After due consideration of my means and circumstances, I decided to adopt the photographic method which had been successfully employed at the Kew Observatory some years ago.

This method alone makes it possible to conduct the operations with all the required efficiency by means of a few simple and

fixed rules, which, once mastered, would require no further skill or judgment in the operators at the instrument, but only a methodical and conscientious attention to the rules. This was a necessary condition which I had to take into account in deciding upon my course.

I will now describe the main principle on which the Kew photographic method is based.

The absolute height and velocity of a cloud, provided it be suitably situated, can be determined from two photographs of it taken simultaneously with two cameras placed at a distance of from a few hundred yards to 1 or 2 miles from each other, the cameras being in all respects equal and rigidly mounted so as to point accurately to their respective zenith—namely, having their collimation axes truly vertical.

If two threads, at right-angle to each other, permanently fixed in a plane parallel to and very near the sensitive film, in such a way that the line passing through their intersection and the optical centre of the objective, is maintained in an invariable position relatively to the body of the camera, and falls perpendicularly to the face of the plate, then, whenever a picture is taken, these threads will be shadowgraphed on the plate, and the image of their intersection may be adopted as the centre of the plate. So that in all plates exposed in a truly horizontal position, a point in the zenith would form its photographic image at this fiducial centre. Such are the conditions required by the Kew method.

Having photographed a cloud under these conditions we obtain on each plate a picture of the cloud and an image of the respective zenith of the two stations. Let us now superimpose the two pictures, so as to make them coincide exactly.

To insure accuracy in this operation it would be necessary in practice to take a contact print on glass of one picture, and superimpose this positive on the negative of the other picture.

Then it is clear that the line joining the centres of the two plates represents the photographic image of a line joining the two zenithal points of the stations at the height of the cloud, and the ratio of its length to the actual distance between the stations would be the same as the ratio of the focal length of the objective to the height of the cloud, and this height can thus be determined from the data obtainable on the photographs. The process of superposition is, however, somewhat unsatisfactory, and can be obviated by orientating the cameras so that one of the fiducial lines in each is made to coincide with the direction of the line joining the stations.

It is then sufficient to measure on each negative the co-ordinates of any corresponding point in the image of the cloud, taking the centre of the plate as the origin.

This is the system adopted in Melbourne. To obtain the absolute velocity of the cloud, we have only to take a second picture at one or both stations after a short interval of (say) one minute, and measure the displacement of the image which, together with the known height and focal length of the apparatus, determines the actual distance traversed by the cloud during the interval between the exposures. I will now proceed to describe the Melbourne arrangements for carrying out this work. I have here a pattern of the body of the cameras, which will give you an idea of their shape and dimensions.

The instruments are made of heavy cast-iron, and are similar in every respect. Each consists, generally speaking (and disregarding particular detail), of a hollow frustrum of a pyramid with a square base, and having a circular opening at the top, into which the lens is fitted.

Once adjusted, the lens is permanently fixed, and intended to remain in an invariable position with regard to the body of the camera. A shallow rectangular opening at the bottom of one side of the apparatus serves to introduce the dark slide which carries the plates.

On the inner face of the base there are two guides, one of which is plain, and one Λ-shaped on the top. On these rests the dark slide when *in situ*. I have here, also, one of the dark slides for your inspection.

You will notice that the wooden parts are attached to a substantial brass frame, one side of which has a V-shaped groove all along its length, with a stop at one end. This groove fits into the guide within the camera, and thus the slide always occupies an invariable position in respect to the body of the instrument.

The plate, which is a square, whose side is 158 mm., has two of its contiguous edges grounded with a rounded corner between.

When ready for exposure it rests on three steel points, which are fixed on the brass frame, and its two grounded edges are brought in contact with three cylindrical studs, also fixed on the brass frame, while two springs on the opposite sides keep it in that position. So that the plate occupies always an invariable position in respect to the slide, and consequently also in respect to the body of the camera.

The fiducial lines, which are required to determine the centre of the plate and its orientation, are obtained by means of a latent image of a reseau impressed on the plate, which is developed together with the cloud picture.

The reseau consists of two sets of parallel lines, 5 mm. apart, one set being at right-angles to the other. The intersection of the middle lines of the reseau form the centre of the plate.

The reseau process is exactly the same as it is practised in the astrophotographic work of the Observatory, and it is therefore unnecessary to describe it.

The lenses are "Zeiss" anastigmat, series IV, No. 3, focal length 4·41 inches, beautifully paired.

The instrumental adjustments are—(1st) To make the optical axes of the cameras truly vertical; (2nd) To make one of the central lines of the reseau at both stations coincident with the base-line.

The first is made in two steps, as follows:—A small telescope, provided with a micrometer, is mounted vertically on an independent tripod, looking downwards, with its objective a few inches above the photographic lens and central with it. A small dish containing mercury is then placed between the camera and the telescope, and by means of a Bohnenberger eyepiece we observe the reflected image of the telescope wires, and cause them to coincide with their direct image. We have thus made the collimation axis of the telescope truly vertical. The mercury dish is now removed, and a plate containing a developed image of the reseau is placed in the camera in the usual way as if it were exposed for taking a cloud picture.

The centre of the plate is now illuminated by means of a small electric lamp, and we look at it through the telescope.

If its image is coincident with the intersection of the wires in the telescope, then the collimation axis of the camera must be parallel to that of the telescope, and, therefore, truly vertical.

If it is not coincident, the required rectification is made with three levelling screws provided for the purpose.

The second adjustment was made approximately in the first instance by stretching a long wire between two poles on the base line, and orientating the camera simply by the eye, and subsequently, for further and more accurate verification and rectification, simultaneous photographs of the sun were taken on every possible opportunity. The azimuth adjustment is also verified by the condition that the co-ordinate, at right angles to the direction of the base line, ought to be the same in both pictures.

Both these adjustments are very constant, and there has hardly been any necessity to make rectifications since last July.

With ordinary care, these adjustments, once made, remain practically constant for a very long time.

The arc value of 1 millimeter on the plate is about 35′.

The co-ordinates can be measured off the negatives, even roughly, with compass or scale to within a couple of tenths of a millimeter, and, if the cloud points selected for measurement were sufficiently well-defined, the probable error of the co-ordinates might be reduced to half that amount.

Such accuracy, however, is not attainable, owing to the nature of the objects photographed. The pictures have no sharp outlines; their structure is evanescent, and can hardly bear any magnification.

On comparing two-paired pictures we can hardly find two corresponding points which can be satisfactorily marked with the fine point of a compass.

You often think you can do that on some better defined parts; but when the mark is to be made, you know it is only a question of rough approximation.

Consequently it is unnecessary to attempt greater accuracy in the measures than that obtainable with a scale of millimeters. The photographic part of the work gave more trouble than the instrumental questions. It was intended principally to deal with the higher clouds, some classes of which are sometimes barely visible against the deep blue sky.

Yellow screens of different densities were used, with stops no greater than f/32 and exposures from $1/12^s$ to $1/25^s$.

Many experiments were made to determine the best average conditions, with a view to give the work as much uniformity as possible. If it could have been carried on by the same two operators throughout, much could have been left to their experience and discretion, to suit the variable photographic factors to the variable circumstances. But there were four different operators at the far end station, away from the Observatory, who took up weekly duty in turn, and with very little time at their disposal.

It was essential also to avoid any interference with the camera in order to preserve its adjustments, and to facilitate the operations as much as possible.

It would have been undesirable to vary the stop, the time of exposure, and the screen in each case, and the desired effect had to be obtained by an average constant combination of these quantities, subject to alterations, only in very exceptional conditions.

Every possible combination was tried, and at last we found one which seemed to act satisfactorily.

This was $1/25^s$, for the time of exposure f/25 stop, and a screen of medium density call screen No. 2.

It has been possible hitherto to meet almost every exceptional case by sometimes varying the exposure, very rarely using a different screen, and never altering the stop.

In the earlier stages we used Ilford isochromatic plates, which, however, gave continuous trouble and poor results.

The later plates employed were Ilford chromatic, of medium rapidity, and these have given every satisfaction, and are in use at present.

The negatives are slowly developed by the Metol-hydroquinone. The finer cirrus clouds sometimes taking forty minutes or longer to develop.

The two stations are connected by telephone, and are also provided with a telegraph key and sounder, through which time-

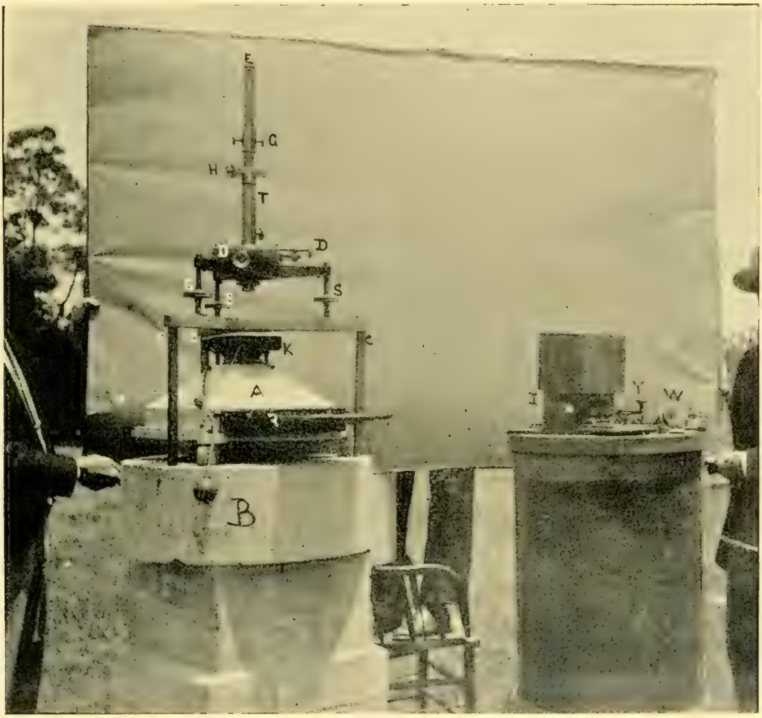
Cloud Observations in Victoria.

By P. BARACCHI, F.R.A.S.

VIEW OF THE CLOUD CAMERA IN THE GROUNDS OF THE MELBOURNE OBSERVATORY

Showing the guides, C C, in the opening, R, for inserting the dark slide.

Cloud Observations in Victoria. *By P. BARACCHI, F.R.A.S.*

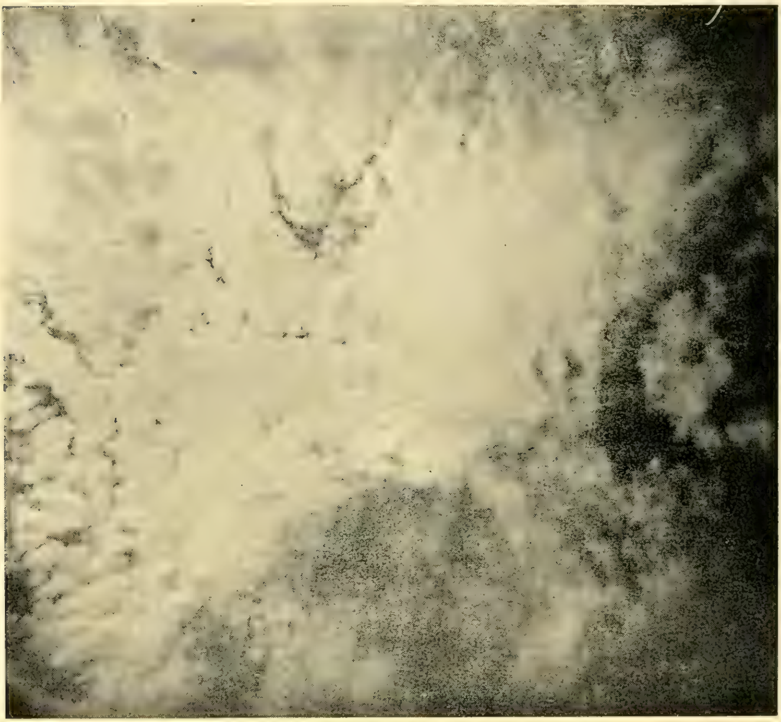


VIEW OF THE CLOUD CAMERA, SHOWING ARRANGEMENT OF APPARATUS FOR TESTING THE VERTICALITY OF THE AXIS OF COLLIMATION.

A The camera, permanently pinned to the stone pier, B.
R The dark slide in position; lid drawn out for exposure.
K Exposing shutter.
C Tripod for the support of testing apparatus.
S Levelling screws for the support of testing apparatus.
T Telescope.
H Micrometer carrying cross wires.
D Slow motion screws displacing the telescope in two directions, at right angles.
G Bohnenberger eye-piece.
W Telephone.
Y Ordinary telegraph key connected with the other station.
I Sounder for telegraphic communication.

Cloud Observations in Victoria. *By P. BARACCHI, F.R.A.S.*

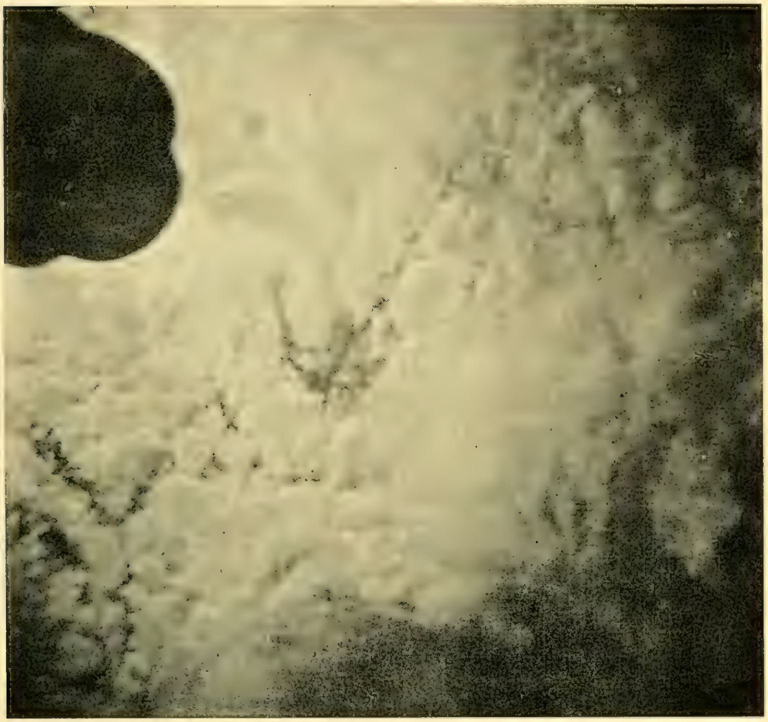
Plate No. $\frac{124}{O}$ taken from the grounds of the Melbourne Observatory.



Pair of photographs taken simultaneously from the terminal stations.
Date, 25 October, 1897, 9h. 31m. 30s. a.m. Exposure, 1-25 sec.
Form Alto-Cumulus. Height of central parts, 21,780 feet.

Cloud Observations in Victoria. By P. BARACCHI, F.R.A.S.

Plate No. $\frac{124}{P}$ taken from the roof of Parliament House, Melbourne.



PHOTOGRAPHIC DETERMINATION OF CLOUD HEIGHT AND VELOCITY AT MELBOURNE.

signals or clock-beats are transmitted by the Observatory according to a code, and the last of a set of five beats sent by hand indicates the instant for exposure, which is made simultaneously by the two observers by means of a Picard shutter worked instantaneously by the usual india-rubber ball method.

The ten pairs of photographs before you were selected amongst the best and the worst. They are enlargements on bromide paper twice the size of the negative. The heights of the respective clouds were determined by measuring a few corresponding points by a millimeter scale, and vary from 17,212 to 37,682 feet.

The fine cirri, though sometimes barely visible on prints, can be measured fairly well; but the direct measures from the negatives are far more satisfactory. Under ordinary conditions the highest clouds can be measured within a probable error of 500 feet.

The illustrations (plates XIII, XIV and XV) show two views of the cloud camera in use at the Melbourne Observatory, and a pair of photographs of alto-cumulus cloud, taken simultaneously from the terminal stations.

No. 11.—THE TESTING OF REFLECTING SURFACES.

By P. Barrachi, F.R.A.S., &c.

[*Abstract.*]

The author, after a brief introduction on Focault's methods of testing reflecting concave surfaces used in various forms of reflecting telescopes, deals with the optical theories upon which these methods depend, and explains, by the aid of diagrams and records of actual experience, how the arduous process of figuring a surface into the required form can be safely guided by a knowledge of the amount of aberration at the centre of curvature, measured in zones over the whole surface at brief intervals during the last stages of the work. This is followed by a description of the apparatus with which these testings and measurements are made. (The apparatus in actual use for this purpose at the Melbourne Observatory was exhibited on the table for inspection.) The paper then treats of the method for testing the combined effect of the two reflecting surfaces of the Cassegrain telescope before they are mounted in the tube. The arrangement of the mirrors under test is represented in attached diagram, in which is traced the path of the rays from their passage through a small diaphram placed in front of the artificial source of light (a small kerosene lamp), to their converging point at E where they enter the eye of the observer.

The details of the special case of testing the two mirrors of the Great Melbourne Telescope, as practised at the Melbourne Observatory, are given at length, showing the separate and combined

values of the aberrations of the two surfaces at their respective centres of curvature, which determine their actual form, and finally indicating the manner in which an error in the curvature of one surface may be compensated by an appropriate correction in the curvature of the other.

In diagram below, which shows the arrangement of the mirrors under test, A is the primary or conave mirror 4 feet in diameter

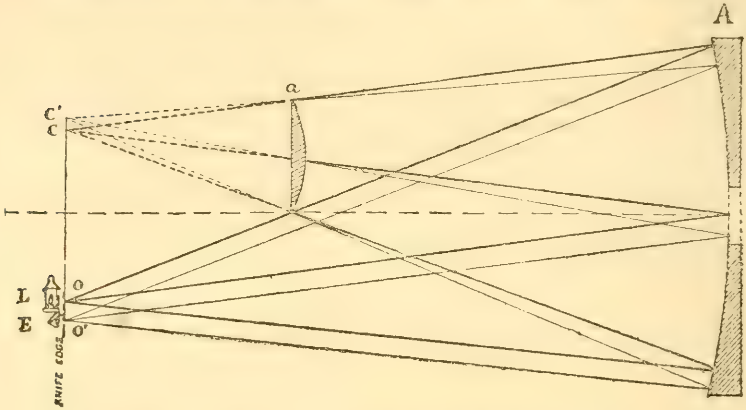


DIAGRAM SHOWING ARRANGEMENT OF MIRRORS OF THE GREAT MELBOURNE REFLECTOR DURING THE PROCESS OF TESTING AT THEIR CENTRE OF CURVATURE.

and 366· inches focus (approximately). *a* is the secondary or convex mirror 8 inches in diameter, and $74\frac{3}{4}$ inches focus. L is the source of light (a kerosene lamp) in front of which is placed a small diaphram O, $\frac{1}{200}$ inches aperture. E is the place of the eye situated behind a small vertical knife-edge O^1, which is capable of being moved with a gentle motion across the line of sight. The diaphram O is located at the centre of curvature of the mirror A, and the mirror *a* is so placed that its centre of curvature C is at approximately the same distance from mirror A as the diaphram O. Then the rays of light diverging from the aperture O fall on mirror A, by which they are reflected towards the point C ; but on encountering the surface *a* they are reflected back along the fainter lines, diverging from C^1, and fall again slightly displaced on mirror A, by which they are again reflected at a point O^1 near the knife edge, from which point the observer views the effect produced when the knife edge is being moved across. The form of the surfaces is determined by the length of the radius of curvature of each of their elementary zones. Wooden diaphrams are accordingly placed before mirror A, by which the whole reflecting surface can be subdivided into concentric rings 3 inches wide, varying in diameter from 45 to 12 inches, one ring at a time

being exposed in succession, while the rest of the surface respectively remains covered. For each exposed zone the point is found along the axis of mirror A, where the knife edge, on being moved transversally across the path of the rays, shuts out the light suddenly and symmetrically from the whole area of the bright ring. This indicates that the knife edge crosses the cone of rays, reflected by that ring, exactly at the vertex, and therefore determines the centre of curvature of the ring. The amount of longitudinal displacement of the knife edge, which is required in order to meet in succession the vertex of the cone of rays reflected by the other rings, determines the difference in the length of the radius of curvature of the successive zones, which displacement is capable of being accurately measured by a micrometer to within $\frac{1}{1000}$ ths. of an inch, or less.

In this manner the form of the primary mirror is first determined separately; then the secondary mirror is introduced, as shown in diagram, and new readings are taken for the combined surfaces. From the data thus obtained, by eliminating the observed aberrations for the great mirror, those of the convex mirror, and thence its form, can be ascertained.

These observations are of extreme delicacy, and require to be carried out in the middle of the night, when everything is quiet, and a fairly uniform and constant temperature can be more satisfactorily attained throughout the buildings where these tests are made.

It is shown, in conclusion, that with the Cassegrain telescope the best definition is obtainable when the form of the primary mirror is a paraboloide, and that of the secondary a hyperbolide; that deviations from these forms in the two surfaces when acting in combination, will generally tend to compensate each other, and will be entirely neutralized when the amount of error in the convex mirror is double that of the concave mirror. Consequently an error in the concave mirror is doubled by a perfectly figured convex mirror; also that an error in the convex mirror is not altered in quantity by a perfectly-figured concave mirror, but is by the latter changed in kind; so that, if overcorrected, it would, in conjunction with the concave, appear undercorrected, or give in combination, the same image as an undercorrected concave surface acting singly.

No. 12.—A GENERAL EXPRESSION FOR FLOW IN TUBES.

By G. H. KNIBBS, F.R.A.S., L.S.

(*Read January* 11, 1898.)

No. 13.—THE SOURCE OF THE PERIODIC WAVES WHICH ARE RECORDED FROM TIME TO TIME ON THE SYDNEY AND NEWCASTLE TIDE-GAUGES.

By H. C. Russell, C.M.G., F.R.S., F.R.A.S., &c.

(*Read January* 11, 1898.)

[*Abstract.*]

Almost from the first day the Sydney and Newcastle self-recording tide-gauges were established—the former in 1867, the latter in 1871—I have found on the daily record sheets from time to time periodic waves recorded with the tidal curves. The period is usually about twenty-six minutes. In 1868 we were surprised by the records of waves of unusual dimensions, some of which caused a rise and fall in Sydney harbour of 3 ft. 6 in. These waves continued to reach our coast and record themselves for four days, *i.e.*, August 15, 16, 17, and 18. Such an unusual display indicated unusual energy somewhere, and the waves were soon explained by the news of the great earthquake at Arica, in South America. One account, given to me by Captain Conlon, who was passing Arica at the time, throws some light upon the character of the waves. He was then the captain of a large steamer running from London to San Francisco, and was passing Arica at the time of the earthquake. "The shocks," he said, "were extremely violent, and everything that was breakable in the steamer, even to the binnacle lamps, was thrown down and broken. It felt as if the steamer was struck violent blows from below, which made her shiver from end to end as if she was going to pieces." From the shore mighty waves rolled away towards Australia across the Pacific Ocean at the rate of 360 miles per hour. At Sandwich Islands they were still 40 ft. high, and at New Zealand they were 6 ft. and in Sydney, as stated above, 3 ft. 6 in.

In 1874 and 1877 and other years we have had similar waves, and I have been able to trace them to reported earthquakes; and in the intervals between these larger disturbances we have had recorded frequently periodic waves of the same character but much less amplitude. At first these were credited to unknown earthquakes, but from time to time instances occurred when earthquakes took place and there were no periodic waves. Some of these were evidently due to great storms in Tasman Sea, but

there were many not explained. Then came the great earthquake in New Zealand, on June 10, 1886, when the Pink Terraces were destroyed, but no periodic waves were recorded; the earthquakes in South Australia, August 22, 1896, and many others which left no trace on our tide-gauges, although in the intervening years many periodic waves were recorded. Captain Allan, the late harbour-master at Newcastle, who had charge of the tide-gauge, observed in a report to me "that when the tide-gauge sheet showed sharp-pointed, oscillating marks, a gale followed within forty-eight hours, accompanied with high tide and heavy sea." He continued:—"I also have observed that, although the tide-sheet may show considerable oscillation of a rounded character, it is not always followed by a gale. It is only when the pencil shows sharp-pointed, zig-zag lines along the tide curve that a gale may be looked for, and the more defined and the greater the range of these zig-zag lines the heavier the coming gale." The frequency of these periodic waves had long before led me to look amongst ordinary meteorological conditions for something which would give rise to them; and the daily weather-chart, giving a synoptic picture of all the weather conditions, made evident the possibility of the origination of an impulse such as would generate waves.

About every seven days an anticyclone passes over Australia, and between one area of high pressure on the next one, there is always an area of low pressure called a Λ depression in which is the lowest barometer, and the sides of the Λ have the steepest grades, on the preceding side of the Λ are strong N. to N.E. winds, and on the following side strong S. to S.W. winds. The change of winds is sudden and the southerly winds is one of the strongest we have.

The barometer sometimes falls to 29·000. Under such a low pressure the sea rises and currents set in on all sides except the north, and there the mainland of Australia is found and cannot supply the demand for water, so that the currents into the Λ set in from the other sides. During this time the whole system is travelling to the east, accelerating the currents into the centre, until when it approaches Bass Straits all the easterly current is cut off by Tasmania, except that which comes through Bass Straits; meantime the falling barometers have accelerated the constant southerly set of the east coast current, making it a very strong northerly current which meets the storm centre; with its westerly and southerly currents in Bass Straits, a confined area, in which by the meeting of these currents, the waves are set in motion which we find recorded on the gauge. This southerly setting current is so vigorous that it continues to set to south in opposition to the strongly opposing southerly winds which meet it as the centre of the Λ depression passes. This fact is well known; Captain Dawson of H.M.S. "Waterwitch" informed me that it was well known

that the stronger the southerly wind the stronger was the current setting south against it. The strength of the southerly depends upon the depth of the Λ depression, and the lower the barometers, the more the southerly setting current is accelerated. The theoretical condition given above therefore is in exact accordance with the observed conditions.

This becomes more evident if the contour of the coast lines is examined, for the south coast of Australia and the west coast of Tasmania converge into a funnel-like area, in which the wind and sea currents generated by the low pressure converge from opposite directions, and meeting in this comparatively confined area generate the periodic waves which are recorded on our tide-gauges at Sydney and Newcastle.

We find that the lower the barometer in the Λ is as compared with Sydney the greater are the waves recorded on the tide-gauge.

It is of importance to note here, that there may be a very low depression travelling along the south coast rapidly, in some cases at twice the usual speed; and when this is the case, as shown by many instances carefully examined, there are no periodic waves, such as are found when the low pressure is travelling slowly, and the reason appears to be, that there is not time enough for the ocean currents to be set in motion before the depression has passed by; barometers fall and rise as usual, but the ocean is not sensibly affected, for water takes time to adjust itself to the varying atmospheric pressure.

It is a strong confirmation of the foregoing theory to be able to say, after a careful examination of the records since 1867, that 62 per cent. of the cases when periodic waves have been recorded on our tide-gauges, they have been coincident with the passage of Λ depressions such as I have described above.

The probability is that a number of periodic waves are set in motion by storms in Tasman Sea, and of those recorded I have traced 1 per cent. of them to that source, which is as much as could be expected when we remember that in the past the logs of vessels crossing that sea have not been recorded. In Lake George I have had a self-recording anemometer and a tide-gauge at work since the beginning of 1885, and there, periodic waves are very frequently recorded, and clearly shown to be the result of violent gusts or squalls of wind on the lake. Lake George is about 16 miles long (its length is affected by rain) with a depth where deepest of about 20 feet. On the western side there are high hills, and the lake is longest from north to south, so that the wind generally blows up or down the lake; and sometimes a squall of wind will force the water to one end and make it as much as 18 inches above its normal level. The water then flows back and keeps up its periodic motion, flowing backwards and forwards for several days, with a period of 2 hour 11 minutes, the rise and

fall gradually decreasing, until the impulse is spent. I have mentioned Lake George here only because the effects of gusts of wind in producing periodic waves is so very clearly shown in the records of the anemometer and lake gauge, that there can be no doubt as to the connection between squalls of wind and these waves, and the experience gained at Lake George has led me to suppose that it is extremely probable that periodic waves are set in motion by squalls of wind in Tasman Sea.

Upon comparing the reported earthquakes with our tide-gauge records, I found 10 per cent. of the recorded periodic waves on our tide-gauges coincident with earthquakes. We have thus accounted for 73; that is, 10 from earthquakes, 62 from waves in Bass Straits, and 1 from storm in Tasman Sea—in all 73 per cent. of the periodic waves on our tide records—leaving 27 per cent. unaccounted for. I feel sure that a more complete knowledge of the meteorology of Tasman Sea would account for more than half of the 27 per cent. at present unaccounted for.

No. 14.—NOTES ON COMPARISONS OF STEEL AND IRON LINEAL STANDARDS FOR GEODETIC PURPOSES.

By D. M. MAITLAND, L.S.

(*Read January* 11, 1898.)

Section B.

CHEMISTRY AND MINERALOGY.

No. 1.—ON THE COLOURING MATTERS OF WINES.

M. Blunno (*Licenziato in Scienze*), New South Wales Department of Agriculture.

(*Read, Friday, January* 7, 1898.)

[*Abstract.*]

The author refers to and discusses recent investigations in this subject by M. Rosensthiel and Gautier.

It is well known that the juice, even of red grapes, is nearly always colourless. This was attributed to the insolubility of the colouring matter in water. Rosensthiel's experiments have however shown that at a temperature between 50° and 70° Centigrade the unfermented juice is capable of dissolving colouring matter.

These colouring matters are very unstable and are attacked by nearly all metals. At such a temperature air is a remarkably powerful decolouriser, and is capable of rendering the red colouring matter insoluble in alcohol.

If unbroken grapes be heated to 50° Centigrade in a hermetically closed vessel, the wine produced in crushing and fermenting these grapes will not be red.

It is therefore necessary to exclude the air if the colouring matters are to be kept unaltered.

These experiments are of practical importance, because the treatment above described not only renders the colouring matters soluble and stable in the must, but destroys the Saccharomyces, while germs of mould and bacteria are hindered from developing.

It would from this appear quite possible to destroy the natural ferments by pasteurizing must and skins together at 50° centigrade, such treatment being without effect upon the colour and taste of the resulting wine.

Rosensthiel recommends heating three times to 50° when all natural ferments are destroyed and fermentation may be brought about by means of selected yeasts.

When suitable appliances shall have been devised for carrying out this operation on the large scale, the problem of the use of *levures pures* will have been solved.

M. Gautier's experiments to which the author next drew attention, have reference to the chemical composition of the colouring matters of wines. M. Gautier finds that each variety of grapes has its special pigment which differs in its centesimal composition from those of other grapes.

Further, on cross-breeding between two varieties of grapes, the cross-bred contains a new colouring matter whose centesimal composition is the mean of that of its parents.

Gautier draws the conclusion that in cross-breeding there are not only morphological, histological, and physiological variations, but that even the chemical substance of the cells undergoes variations, and puts forward the suggestion that the variation of species may be due to chemical changes which take place within the molecules of the tissues and protoplasm.

No. 2—THE MOLECULAR MECHANISM OF AN ELECTROLYTE.

By W. M. Hamlet, F.I.C., F.C.S.

(*Read Friday, January* 7, 1898.)

No. 3.—NOTES ON THE COLOURING MATTER OF *ERIOCOCCUS CORIACEUS*, AND THE WAX OF *CEROPLASTES RUBENS*.

By E. H. Gurney.

(*Read Friday, January* 10, 1898.)

[*Abstract.*]

I. ERIOCOCCUS CORIACEUS.

The scale insect, *Eriococcus coriaceus*, is generally found encasing the young shoots of the Eucalypti, especially those springing from old or burnt stumps.

It occurs around the stems in closely packed clusters of small pinkish-white sacs.

It is of rather frequent occurrence all over New South Wales, though it probably exists in quantities too small to make it of commercial value.

The following analyses may be regarded as fairly representing its composition :—

Moisture	19·91	18·49
Volatile and organic	77·44	79·00
Ash	2·64	2·47
	99·99	99·96

The scale, treated with solvents, gave the following percentages of extract :—

Cold water	17·35 per cent.
Cold ether	22·56 ,,
Boiling ether	31·50 ,,
Cold absolute alcohol	27·81 ,,
Boiling ,, ,, ...	34·53 ,,

Wool and silk dyed with this colouring matter, and mordanted with aluminium, tin, chromium, and iron, produced the following colours :—Light amber, light orange brown, brown, and sage green respectively.

In these experiments no colours of any great brilliancy or distinctiveness were obtained, and with alkali all the colours were changed more or less to a pinkish or purplish tinge.

These facts, taken in conjunction with the somewhat scarce source of supply, and the position of the azo and alizarin colours in the dyeing industry, would seem to point out that the colour of this scale is valueless as a dye.

In volumetric work, used as an indicator, this colour proved as delicate as cochineal and litmus, but, owing to the very faint indication which it gives of the change from acid to alkaline solutions, and *vice versâ*, it is of no particular value in such work.

II. CEROPLASTES RUBENS.

The wax-bearing scale insect, *Ceroplastes rubens*, occurs in only one or two localities in New South Wales, though in Queensland it is considered as a destructive pest.

The scale has a pinkish-white appearance, and when thrown into water, floats upon the surface. The brittle shell of wax is easily broken with the finger, and is not very sticky when handled; it has very little taste.

The scale, heated and strained through a fine cloth, gave 38 per cent. of wax ; whilst extracting the scale with solvents the following percentages of wax were obtained :—Absolute alcohol, 83 per cent. ; ether, 86 per cent. ; and benzine, 88 per cent.

The melting point of heat-extracted wax was 60° C., and that of wax extracted by solvents 55° C. Specific gravity of wax at

23° C was 1·03. Upon organic analysis, 100 parts of purified wax gave C 78·22, H 11·01, and O 10·77, therefore the composition of the compound was supposed to be $C_{10}H_{17}O$.

A comparison was made between this wax and that of the scale *Ceroplastes ceriferus* :—

The details in connection with the wax of *Ceroplastes ceriferus* were taken from *Indian Museum Notes*, Vol. II, No. 3, on "White Insect Wax in India."—E. C. Cotes.

	Ceroplastes ceriferus.	*Ceroplastes rubens.*
Melting point ...	60° C. 55° C.	60° C. 55° C.
	At 15° C.	At 23° C.
Specific gravity ...	1·04	1·03
Supposed composition of wax, calculated from percentage composition ...	$C_{13}H_{26}O$.	$C_{10}H_{17}O$.

The wax has no value as a varnish, and it burns with a smoky flame and resinous smell.

The supposed formula $C_{10}H_{17}O$, must be considered as tentative only, until further combustions have been made upon larger quantities of purified wax.

No. 4.—METALLURGICAL METHODS IN USE AT BROKEN HILL.

By G. H. Blakemore.

(*Read Saturday, January* 8, 1898.)

I have ventured to think that a short history of the methods of ore treatment in vogue at Broken Hill of this Colony, may be of some small interest to members, more particularly to those interested in the mining and metallurgy of silver ores.

To most mining people there is a never ending interest in the methods of ore treatment followed in the various parts of the world ; in the complications arising and the difficulties experienced in the several operations leading to the successful financial end that shareholders naturally expect. Too little is known or written on the vast subject of metallurgy, no matter of what metal (if we except steel and iron), and a wider spread general information would have saved the untold sums of money which ignorance has wasted. Too little credit is given by practical mining men to the

advantage of a scientific education and its achievements, and it is a well known truth that the money paid to a mine manager of latter day attainments is grudged, whilst assayers and metallurgists are looked on as luxurious superfluities.

Time and investors' common-sense will put an end to idle superstitions such as these, and the hour is coming here, as it has done years since in America, where the practical miner takes second place to the educated man. All these truisms simply help me to say that Broken Hill has suffered in the past from such mistakes as these; but the good sense of the old directors of the Proprietary Mine asserted itself, and brought out to the country such men as Patton, Schlapp, and Howell, whose methods of mining and treatment of silver lead ores on a large scale are a standing object lesson to the Australian mining world.

I do not propose, in this paper, to deal with the mining part of the question, but simply to take up the methods of ore treatment adopted at the Proprietary Mine, which practically describe the metallurgy of silver and lead in Australia.

ORE TREATMENT.

This will be described in the following order:—Blast-furnace smelting, lixiviation and chloridising, amalgamation and concentration.

Smelting.—One great drawback to the smelting operations was the irregularity of the composition and value of the ore, and the absence of bedding floors at the furnaces, for the ore to be received in as it came from the mine, made this point more acute, and, together, have caused great monetary losses to all the companies who smelted their own ore. The following series of analyses of the smelting ores of the Broken Hill Proprietary Mine will show how the ores varied, and this variation took place not daily, but hourly, requiring constant care and attention to get the best work possible from the furnaces at the minimum of cost.

Manganese Ironstone (used as flux).

Pb %.	Ag; ozs.	Fe %.	Mn %.	CaO %.	Al_2O_3 %.	Zn %.	SiO_2 %.
17	3·00	15·0	21·0	·90	8·0	2·6	11·4
15	4·0	14·4	22·8	......	6·5	1·3	15·7
20·0	2·0	14·0	24·6	......	......	......	11·4
19·0	3·0	11·4	27·2	......	......	......	10·8
19·0	2·0	12·9	26·4	......	......	......	8·8
31·0	1·40	3·10	27·6	......	......	......	10·6
17·0	2·0	17·0	22·0	......	......	......	11·0
17·0	4·0	13·5	22·0	......	......	......	18·00

Silicious Ironstone (partly regarded as flux).

Pb %.	Ag ; ozs.	Fe %.	Mn %.	CaO %.	Al_2O_3.	Zn %.	SiO_2 %.
15·5	32·0	12·4	16·8	1·5	6·4	1·4	20·0
14·0	39·0	12·4	14·8	......	8·0	1·7	22·7
11·0	32·0	10·2	16·8	......	......	......	32·8
15·0	9·0	10·8	18·6	......	......	......	29·0
11·0	13·0	10·0	16·8	......	......	......	32·8
16·0	26·0	13·5	16·6	......	......	......	28·6
15·0	17·0	11·3	17·7	......	......	......	29·8

Kaolin Ores.

Lead %.	Ag ; ozs.	Fe %.	Mn %.	CaO %.	Al_2O_3 %.	Zn %.	SiO_2 .
13·0	60·0	12·8	14·4	0·9	14·8	1·20	33·0
8·0	62·0	13·0	11·2	......	14·4	3·25	33·0
8·0	39·0	......	......	......	......	......	......
10·0	19·0	......	......	......	......	......	......
8·0	19·0	......	......	......	......	......	......
9·0	29·0	......	......	......	......	......	......
10·0	21·0	......	......	......	......	......	......

Carbonate of Lead Ores.

Pb.	Ag.	Fe.	Mn.	CaO.	Al_2O_3.	Zn.	SiO_2.
24·0	12·0	6·0	4·5	0·6	8·4	2·0	30·3
37·4	17·60	3·77	1·38	......	......	......	25·0
29·0	20·0	4·9	3·0	......	8·0	2·4	40·2
15·0	31·0	......	......	......	......	......	......
14·0	67·0	......	......	......	......	......	......
12·0	13·0	......	......	......	......	......	......
15·0	23·0	......	......	......	......	......	......
17·0	26·0	......	......	......	......	......	......

Crude Sulphide Lead Ore.

Pb.	Ag.	Fe.	Mn.	CaO.	Al_2O_3.	Zn.	SiO_2.
28·0	19·0	3·8	1·2	......	1·2	16·4	25·5
26·0	16·0	3·6	1·2	......	2·1	15·12	26·4
21·0	16·0	......	......	......	......	22·0	......
24·0	13·0	......	......	......	......	40·0	......
25·0	14·0	......	......	......	......	37·0	......
22·0	15·0	......	......	......	......	20·0	......
32·0	15·0	......	......	......	......	29·0	......

Sulphide Concentrates.

Lead, per cent. ...	60	55	66	66	69	67	65	64
Silver, oz.	21	19	19	22	21	23	20	19
Zinc, per cent. ...	8	9	8	8	8	7	7·6	10

The chief end that the metallurgist in charge had to keep in view was the output. He was not asked simply to smelt the ores, but was also required to vary the charges in such a way as to keep the weekly returns of silver and lead nearly even. The silicious kaolin ores are the chief source of silver, and a glance at the assays given above will show how these vary in value and composition, and, as pointed out previously, not daily but hourly.

The indicator of the daily output was the assay of a small sample of lead, called the "dip sample," taken directly from the "well" of the furnace once every twelve hours, and, as the assay showed a rise or fall in silver, the charge was changed accordingly. For instance, if the "dip assay" showed a drop in silver, and the returns were not good enough for the part of the week which had elapsed, it was often necessary to sacrifice a nice, economical charge on the furnace, and replace some low grade basic ore by the silicious and troublesome kaolin ore to raise the value of the bullion, and, correspondingly, the week's output. Or the reverse condition might have to be considered. It is simply impossible for the mine to regulate the assay value of the ore (which is the sole thing the mine part of the organisation looks at), because in the kaolin stopes the faces may be all or part in low grade ore for some hours, perhaps days; and without any change in the appearance of the ore, the assays suddenly rise or fall. In a large mine such as the Broken Hill Proprietary, where the demand made by the furnaces is great and imperative, it is impossible to keep the ore stored in the stopes until the assay value is known, and usually the ore is in the smelter bins, and probably in the furnace, before the underground manager knows its value. This is not an advantage, especially if we regard it from the metallurgist's point of view, who is asked to keep the return steady, otherwise it is seldom that any absolutely useless ore is sent to the furnaces for the want of the assays or means to store it underground. One needs to see and know the tremendous ore body of the Proprietary Mine to quite grasp this assertion; but if I say that all the ore carries silver, whether the lode is 300 feet wide or 3 feet, it will be readily understood that, with constant experience of the peculiarity of the ore, the underground manager can judge very closely from his previous results what the average value of the ore will be each day; but it is to be clearly understood that there is no absolute guide to the ores' value except experience of the ore body's idiosyncracies, when assays are not available at once, nor any

economical means which can be used to allow of the ore being stacked underground until the results of its value are out. The demand on the mine by the smelters partly brings about such a condition of irregular values in the ore, and nothing can be devised to remedy it, when a mine has a body of ore which is so eccentric in value as that of the Proprietary, and has to keep up its weekly tonnage and output, except large bedding floors. From these remarks, the study may be slightly seen which the man in charge of the furnaces has to make of the character of the ores being smelted. Regarding the slag that will be made, he contents himself by forming an opinion of the silica contents of the ore as it lies in the furnace supply bins, and on that opinion adheres to or changes the running furnace charge. In addition to that, he studies his furnaces and notes all the various signs of the tuyeres, the way the molten slag fall into the slag-pot, the speed the furnace is smelting, &c., and with practice will make the right change; but so often does the character of the ore alter from silicious to basic, and *vice versâ*, that it is not uncommon to have to make from two to six radical changes in the constitution of the ore charge every day. Experience of the ores one must therefore have to attempt to run the Proprietary blast furnaces under the ruling conditions. The absence, then, of bedding floors, with such a variable ore, is a serious detriment to good smelting. The skill of the most accomplished metallurgist would be at fault without he possessed the power to judge, fairly accurately, the ore in the bins each morning, and even with long practice mistakes are made very often, for a man cannot last the whole twenty-four hours of every day, and therefore does not see the ore which is delivered from the mine during the night; and the basic or silicious change which he had made in the charge the previous afternoon might have been unnecessary if the ore could have been seen by him before hand. Hence for some hours an entire waste of flux has gone on, which gets to be serious with eighteen furnaces in full blast. I am somewhat afraid that my metallurgical critics may not quite understand the points in this ore irregularity and the impossibility of arresting it, and probably describe the method of the metallurgist as more guess work than brains, and therefore it is well to say that the "guessing" point of the problem is assisted in every way by regular daily assays of the ores with their principal component parts, such as silica, iron, manganese, and zinc, together with careful bi-daily slag analyses and slag assays from every furnace, made for lead and silver, together with special samples of slag for the same metals taken promiscuously from the furnaces during each day. With the aid of these very close work can be done, and the ability to judge the molten slags, as to their lead and silica contents, is also of the very greatest assistance to the general end.

This digression, if it can be so called, is rather long, but it is well to have plainly understood some of the difficulties which had to be overcome before in reality a pound of ore could be smelted.

THE BLAST FURNACE PLANT.

The furnaces belonging to the Proprietary were 16 in all, divided into two sheds, called the north and the south smelters. The firstnamed contained 9 brick-shaft furnaces 60 inches by 112 inches inside measurement. The 9 furnaces were supplied with air from a common main, the blast being supplied from 6 No. 7½, 1 No. 5, and 3 No. 4½ Baker Positive Blowers, driven by a pair of horizontal compound surface-condensing engines, 16½ inches and 26 inches cylinders by 40-in. stroke. A stand-by engine was of the marine type, and was styled a tandem compound condensing engine, cylinders 14 inches and 24 inches, with a 30-in. stroke. Steam was supplied from 2 Lancashire boilers, 7 feet diameter and 23 feet long, and 2 Cornish boilers 6 feet diameter and 25 feet long, fitted with 1 5-in. by 4-in. by 8-in. Knowles and 1 5-in. by 6-in. by 8-in. Tangye boiler feed pumps.

All the 9 furnaces delivered their smoke, by means of downcast flues, into a common culvert delivering into a wrought-iron stack 196 ft. high and 11 ft. in the clear at the top.

The slag was hauled away from the furnaces in two-wheeled slag-pots by manual labour; later on it was handled with large pots, two on a carriage, each pot holding about 1 ton of slag, horses doing the haulage.

On the feed floor the charge wheelers were elevated from the ore bins to the level of the feed floor by 8 hydraulic automatic lifts with 7-in. rams. All slag, matte, flue dust, dross, &c., that had to be returned through the furnaces were lifted by a double-friction hoist, 7-in. diameter cylinder and 10-in. stroke.

The south smelters consisted of 6 brick-shaft furnaces, 60 inches by 112 inches, and 1 small matte furnace. The products of combustion were drawn off into a common flue and distributed into the air through an iron stack about 150 feet high and 10 ft. 6 in. in the clear at the top. As with the first set described, the furnaces were supplied with air from a common blast pipe. The air was supplied from 5 No. 7½ Baker Positive Blowers, actuated by a pair of horizontal engines, cylinders 16½ inches and 38 inches stroke, and 1 Westinghouse standard engine, 15½ inches cylinders and 14 inches stroke, as a relieving engine.

Steam was supplied from a nest of 5 Lancashire boilers, each 7 feet diameter by 23 feet long, fitted with 1 No. 4 Knowles' and 1 No. 5 Blake boiler feed-pumps. In addition to supplying the south smelters with steam, this installation of boilers supplied the pumping plant, which handled the cooling water of both nests of furnaces.

In the pump house are the following:—

1 horizontal compound condensing engine, 16½ in. by 26 in. cylinders by 48 in. stroke.
2 sets of double plunger pumps, 9 in. by 36 in.
1 set bucket pumps, 12 in. by 24 in.
1 Knowles' compound condensing pump, 16 in. by 26 in. by 24 in. and 17 in. plunger.
1 Tangye steam pump, 10 in. by 6 in. by 24 in.
1 Blake bucket pump, 10 in. by 8 in. by 24 in.
1 Blake double plunger pump, 10 in. by 10 in. by 18 in.
1 Worthington duplex tank pump, 16 in. by 16 in.
1 Worthington compound pump, 6 in. by 10 in. and 10 in. by 8½ in. cylinders.

All the water from both sets of furnaces delivered into cooling dams, from whence it was elevated by the above pumps to large wrought-iron tanks situated at a higher level than the furnaces, and from these tanks the jackets of the furnaces were supplied.

The whole of the works and slag dumps are lighted by electricity, and are connected with telephone to the general office.

In addition to this large and efficient plant, the Proprietary also leased the three 100-ton blast furnaces on the British Mine. A description of these furnaces will be given further on.

The complete equipment of a lead blast furnace plant at Broken Hill is a matter of some expense. According to the number of furnaces, so the size of the engine increases, unless combined engine and blowers are used, with building and flue space. For a single blast furnace of what is known as a 100-ton furnace, the following material is required, exclusive of engine building, flues, and stack:—

	£	s.	d.
1 Blast furnace at foundry (ironwork only)	1,000	0	0
2 100 I.H.P. Lancashire boilers, each £450	900	0	0
1,500 red bricks, £3 15s. per 1,000	5	12	6
2,500 fire bricks for crucible and flue, at £10 per 1,000	25	0	0
11 casks of English fireclay, at £7 per ton	21	0	0
1 No. 7½ Baker or Roots' blower	400	0	0
1 Steam pump of 30,000 gallons per hour capacity	250	0	0
4 Trucks for slag, &c., £12 each	48	0	0
4 Bullion trucks, £3 each	12	0	0
1 1-ton Avery scale	20	0	0
24 Slag-pots, each £6 10s.	156	0	0
30 Bullion moulds, each 15s.	22	10	0
Frame for same	3	0	0
200 ft. canvas hose	10	0	0
100 ft. 1-in. India-rubber hose	5	0	0
100 ft. 2-in. ,, ,,	12	10	0
2 Lead coolers and frames, each £5	10	0	0
6 Ladles, each 6s. 6d.	1	19	0
6 Skimmers, each 5s.	1	10	0
Steel for tapping bars and for barring crust off furnace walls	10	0	0
4 "Stoppers" for stopping slag, each 7s. 6d.	1	10	0
1 Set 1 in. steel letters for branding bullion	0	12	6

	£	s.	d.
1 Set 1 in. figures for branding bullion	0	12	6
7 Wrought steel barrows for wheeling ore charges, each £2 15s.	19	5	0
2 Coke barrows, each £4 10s....................	9	0	0
1 Pot for re-melting scrap lead and sweating lead from dross	20	0	0
1 Hoist for elevating bullion, slag, flue-dust, &c....	195	0	0
4 14-lb. sledge hammers and handles, each 10s. 6d.	2	2	0
12 No. 5 short-handled shovels, each 3s................	1	16	0
6 Long-handled square-mouth shovels, each 3s. 6d.	1	1	0
1 complete set of spanners to fit all nuts	4	0	0
1 8-beam charging scale..	50	0	0
Labour of erecting furnace and fittings	150	0	0
	3,369	0	6

Spare Parts.

	£	s.	d.	£	s.	d.	£	s.	d.
2 Lower end jackets, each	£4	10	0...	9	0	0			
4 Corner ,, ,,	5	0	0...	10	0	0			
4 Side ,, ,,	4	10	0...	18	0	0			
12 tuyeres and corners complete, each	1	12	6...	19	0	0			
Water jacketed slag spouts, each	1	5	0...	6	15	0			
Solid slag spouts, each	0	10	0...	1	10	0			
3 Separators complete, each...	1	15	0...	5	5	0			
3 Separator covers, each	0	2	6...	0	7	6			
6 ,, water-breasts, each	1	5	0...	7	10	0			
2 Bullion spouts, each	0	6	0...	0	12	0			
6 Slag-pot handles, each	1	0	0...	6	0	0			
6 ,, bowls ,, ...	1	12	0...	9	12	0			
6 ,, axles ,, ...	0	5	0...	1	10	0			
200 ft. canvas hose for wind-pipe				10	0	0			
100 ft. 1 in. India-rubber hose				5	0	0			
100 ft. 2 in. ,, ,, ...				12	0	0			
Cord and copper-wire to bind on the hose				1	0	0			
							123	1	6

Blowing-in Expenses.

	£	s.	d.	£	s.	d.	£	s.	d.
30 tons dry wood, at, say ...	0	14	0...	21	0	0			
15 ,, lead at market price, say	13	0	0...	195	0	0			
35 tons of slag, cartage—cost per ton	0	1	6...	2	12	0			
5 tons coke, at per ton	3	7	0...	16	15	0			
4 ,, limestone, at per ton	0	14	0...	2	16	0			
4 ,, ironstone, ,, ...	1	1	0...	4	4	0			
Coal for steam, 10 tons, at per ton	1	15	0...	17	10	0			
Labour about furnaces				20	0	0			
Water, 20,000 gallons an hour required for jackets, for 96 hours—pumping costs at 1d. per 1,000 galllons.........				8	0	0			
Evaporation, loss, and leakage, 8,000 gallons, at 4s. per 1,000 gallons.........				1	12	0			
							289	9	0
Total..................................							£3,781	11	0

At this point the expenses incurred are then charged to the ore-smelting account. They serve to show what the bare furnace, and starting it in work, costs without building, engine, fuel, or stack. No estimate has been given of these, because the condition of one furnace by itself does not exist in Broken Hill ; all the smelting works there being on a much larger scale, with everything to correspond as regards building, flue, and stack capacity.

[A general design of a complete plant with two brick-shaft furnaces and space for others was exhibited.]

THE WORK ON THE FURNACE.

The old style of oval-shaped (horizontal section) 30-ton blast furnace, with a short iron stack through the roof to carry off the smoke—with which the era of lead-smelting was inaugurated at Broken Hill—is now obsolete, and the sight of three or four of these old furnaces on the scrap heap of the mine forcibly brings home the advancement which has been made in the general construction of the lead-blast furnace.

The first radical change in design was made when Mr. H. H. Schlapp, late Metallurgist of the Broken Hill Proprietary, introduced the present furnaces at Broken Hill. Alterations were made in these by Mr. Schlapp, which improved them and at the same time made them "handier" furnaces, and since Mr. Schlapp's departure from Broken Hill, other small improvements, such as the introduction of the Matthewson matte separator, have assisted toward more economical work, which the fall in the silver market and assay contents of the ore demanded.

At the British Mine, a more important change was made in the design by Mr. John Howell, who substituted mild steel jackets for the brick shaft of the furnace of Mr. Schlapp's design ; and for ores which contain sulphide of lead, my experience has undoubtedly shown that this change has been a most important one. One great trouble in a lead furnace when smelting sulphide ore, with or without zinc, is the manner in which the sulphide causes the formation of "crusts" or "scaffolds" in the furnace at a point about 12 inches to 18 inches below the level of the top of the ore charges in the furnace. As the lead sulphide reaches the smelting zone of the furnace, part of it sublimes and ascends through the loose ore and deposits again on the cooler walls of the furnace. With a brick furnace, the walls of the shaft are never so cool, of course, as the water-jacketed shaft mentioned, and the sulphide of lead and zinc seems to incorporate itself with the bricks, as if it were a part of the original erection. When this crust grows to such a size as to materially interfere with the working of the furnace, it is usual to "run the furnace down," to use a technical term, or, in other words, stop putting fresh charges into the furnace and allow the level of the ore and fluxes to sink

until it gets considerably below the obnoxious crust or scaffold. Then the blast is taken off the furnace, and the crust is prised off with heavy 1½-inch diameter-octagon steel bars. The disadvantage of the cementation of the crust with the brick walls is then seen. The crust being all of a dull, red heat, you may chip pieces off with laborious effort, but that is all. If you attempt to clean the walls to the original form of the furnace, you find that the crust has become part and parcel of the brick shaft, and the latter gets very much damaged in the operation.

With the water-jacket walls the crust is a very different concern. Instead of being a solid, tough, and immovable obstruction, you find that there is but one place in it that is hard, which, naturally, is the face exposed to the heat of the furnace. Behind this hard face is a mass of loose ore, which falls away as soon as the hard shell on the outside is destroyed. Then the crust does not form any sooner on the cold water jacket than it does on the brick shaft, because the attrition of the descending ore charge has effect on its peculiar form, and it is much more easily removed from the cold iron face, usually in six hours, leaving the furnace its original size. With the brick shaft this may take twelve to eighteen hours, and when left at that is not anything like clean, through the fact of the crust having filtered into the pores of the brick, and made itself a part of the structure as before described. Much has been said against the water-jacket shaft on the ground of increased fuel necessary through the amount of caloric carried off by the water; but I think a nice looking mathematical calculation is not sufficient to overcome the great advantages which the water-jacket shaft has over the brick, and besides that I never used more fuel with the water-jacket furnace than with the brick-shaft furnace.

It is no uncommon thing to see a number of the brick-shaft furnaces being "burnt out," as it is called, just above the lower jackets. Unskilful work is the natural retort; but I maintain that with the irregularity in composition of the ore, this might naturally be expected. Such a trouble is never experienced with the other style of shaft, and the test of experience has demonstrated indisputably that for good, fast, clean, and cheap work, the blast furnace which is all water-jacketed is the ideal model lead-blast furnace.

Such a furnace may be described as follows :—

It is water-jacketed throughout. The top half of the furnace consists of hollow wrought steel jackets with a 6-inch water space, three jackets being 9 feet 9 inches deep; the fourth, recessed to carry the flue of downcast, is 8 feet deep. The water is fed in at the bottom of each jacket, with the view of preventing the deposition of any sediment, and the whole of the jackets are connected to make sure of an equal water circulation through them

all. The jackets are supported by lugs, which are riveted on them, standing on an oblong frame-work of 8-inch "I" iron, the corners of which rest on four hollow cast-iron columns or pillars, serving also as waste water-pipes. The jackets are surrounded with an iron strap, making the whole a stiff and strong job. The structure at this stage, and before the lower jackets are put in place on the brick crucible, presents the appearance of a large rectangular box with rounded corners, not having any bottom or top, standing on four legs—the columns.

The lower half of the furnace consists of twenty cast-iron hollow jackets, each 20 inches in width by 57 inches long. There are six jackets on each side, with a circular opening cast in them large enough to allow a water-jacketed tuyere to be entered, and these tuyeres project beyond the jackets into the furnace some 9 inches. Four corner jackets have no tuyere openings, and four end jackets (two each end) have 4-inch openings in them to admit air, but no water-jacketed tuyere.

The water is fed into the top of each of these jackets, and is conducted to the bottom by a passage cast inside the jacket. The escape is from the top, and by having a pipe, bent somewhat to the shape of the letter S, the delivery of the water is effected into a launder at a point 9 inches above the highest point of the jacket, doing away with any chance of steam gathering in it. The launder can thus be made a fixture, and does not require to be moved when a jacket has to be taken out of a furnace, as in the old style of furnace.

All the water from the top and bottom jackets, tuyeres, breasts, separators, and slag spouts delivers into the launder which surrounds the furnace, and this in its turn empties the water into the hollow columns which support the top jackets. From these columns pipes underground carry the water to cooling tanks, from whence it is pumped back to the supply tank for use again. Each of the lower jackets have three lugs for bolts on each outside perpendicular edge, and, in addition to bolting the whole of them together, a binder of 60 lb. steel rails goes around them to stiffen the structure.

The crucible on which these jackets stand consists of a large pan made of ½-inch wrought-iron plate, in which brick is laid with fire-clay to form a basin or well to collect the lead reduced from the ore. The lead is drawn off from this well by a passage in the brickwork, starting at the bottom of the well and passing up and outwards at an angle. This system has been incorrectly styled a "siphon tap," or the "Arent's siphon" after the first user of it, but it is plain that it is not a siphon, the lead simply rising in the passage and obeying the law of all liquids in finding its level.

The Matthewson matte separator is an ingenious arrangement, which takes advantage of the presence of the blast in the furnace

to have the slag forced to deliver at a higher level outside the furnace than it lies inside. It is satisfactory only when small quantities of matte are being produced.

The brick-shaft furnace requires no description other than that the brick shaft is supported on a heavy cast-iron entablature supported on cast-iron columns.

The all water-jacketed furnace just described measured 50 inches wide and 132 inches long at the lower jackets, 34 inches wide between the noses of the tuyeres. It was nearly 17 feet deep from the feed-plate to the bottom of the crucible.

Since these furnaces have been built, much larger furnaces on the same design have been erected at other works, and have given the greatest satisfaction; in fact, it may be safely said that the days of the brick furnace are over in all newly erected smelting plants.

The "blowing-in" operation, or starting of one of the blast furnaces, requires experience, and a sharp eye kept on all that is going on. At the risk of being prolix, I will describe the actual operation of starting a lead-blast furnace.

From two to four days before the real start is made, a drying warming fire is lighted in the brick crucible. The water-pump is started, and water turned on to all the cast-iron and wrought-steel jackets, tuyeres, and separator breasts. Usually there is a separator at both ends of a large furnace, and when the fire is lighted, one of these separators, breast and slag spout, is taken out of the furnace to leave an opening through which the wood is passed into the crucible. As soon as the bricks of the crucible begin to warm up, the engine driving the blower is started (or in a nest of furnaces the blast is let into the "bustle-pipe" from the main blast or air-pipe), and the fire is urged by the wind thus forced into the furnace. Care is taken that a plentiful supply of water is kept in all the parts of the furnace that would otherwise get heated. The 15 tons of lead requisite to fill the crucible is now melted in with the aid of the wood fire (urged by the blast from the blower) in lots of twenty-five to fifty bars at a time. This usually takes eight or twelve hours, and it is not advisable, though quite possible, to take less time, inasmuch as the lead would not retain sufficient heat to keep it molten for the few hours required, after the furnace is closed up or started, before the furnace begins itself to produce lead from the ore. Immediately all the bars of lead are thoroughly melted in, the whole of the hot ashes and coals from the wood are then skimmed off the lead, leaving it almost quite clean. Too much time must not be wasted over this operation, for the molten lead in the crucible is cooling while exposed to the air. It is also very necessary to get these ashes out, because if left in the furnace they form what is called a "crust" over the well or crucible, which acts as a shield, and prevents the lead reduced in the smelting operation from

getting into the crucible, so allowing the lead of the well to chill from want of fresh supplies of heated lead, most probably causing a "shut down" of the furnace.

As soon as the ashes are all out, some deal, or any easily ignited wood, is thrown on the face of the molten lead, which last should be hot enough to ignite the chips in a few moments. The corners of the furnace are well supplied also to make sure of a good fire all over the crucible. The heavier wood is then thrown in, and the mason then puts back the separator, breast and slag spout, having all necessary bricks cut the exact size required beforehand, so that the least possible time may be consumed from this time on until the blast is put on the furnace. Immediately the mason has secured the separator and its parts in place, more wood is dropped into the furnace from the top floor, through the feed opening, until the tuyeres are just covered with wood. If the flames have not obtained a good hold of the wood you must wait a little. As soon as you are satisfied that the fire has a good enough hold of the wood, some 1,600 pounds of coke is emptied into the furnace out of bags, which have all been weighed up in readiness. Then the following charges are shovelled into the furnace as rapidly as the eight or nine men on the furnace can do it. I might say that the first 50 of the charges given below are weighed up and stacked on the floor around the feed-opening of the furnace, each charge being divided off from the next with a piece of wood. This weighing-up is done to facilitate the filling-up of the furnace when every moment is precious.

BLOWING-IN CHARGES.

25 charges of		
Slag	750 lb.	900 lb.
Manganic ironstone	75 ,,	
Limestone	75 ,,	
Coke	125 ,,	
25 charges of		
Slag	500 lb.	925 lb.
Carb. lead ore	275 ,,	
Limestone	75 ,,	
Manganic iron	75 ,,	
Coke	125 ,,	
50 charges of		
Lead ore (carbonate)	325 lb.	950 lb.
Silicious iron	150 ,,	
Manganic iron	75 ,,	
Limestone	200 ,,	
Slag	250 ,,	
Coke	125 ,,	
Then regular charges		1,000 lb.

After the first 15 charges have been put in, 10 bars of lead are dropped into the furnace; after the next 15 charges, 10 bars more; after the next 25 charges come 10 bars of lead; and for, say, 50 charges afterwards, 1 bar of lead is fed in with each charge. This is done to get a lot of lead into the crucible quickly, for this additional lead, being heated to bright redness in its descent in the furnace, accordingly raises the temperature of the lead in the well or crucible, and stops the risk of the lead "freezing up" which we first saw melted in.

While the men are filling up the furnace, you see that the tuyeres are all closed on the furnace, so that no gases from the wood can get into the main blast-pipe and cause damage by exploding; that all the jackets are keeping cool and the "siphon" from the lead well to the outside of the furnace is not choked up and has a bright fire on it. In fact, give a look around to see that nothing is missing or wrong, so that the blast may be turned on the instant the furnace is filled up. With the wood and coke which were first put in, 40 of the blowing-in charges fill the furnace to within 6 feet of the feed floor. Then, sending all the slag men down to their proper stations, the blast is turned on at a pressure of about 3 to 4 oz. to the square inch. In a very few minutes every joint between the water-jackets is smoking, if they have not been well rammed with fire-clay.

Wet clay is placed on the smoky places to check it, because after a while these streams of smoke catch fire, and sometimes burn the windbags; and, if they do not, the smoke from wood is not the most pleasant substance to get into one's eyes.

About twenty minutes after the blast has been turned on, the smoke all ceases, through the furnace beginning to smelt the charges which have just been put in; the first slag formed chilling on the jacket and closing the cracks. Then the tuyeres are examined frequently to judge how the slag is forming. In an hour and a quarter to one and one-half hours after the blast goes on, the first slag can be tapped from the furnace. The slags first produced by the furnace are purposely made lower in silica than those produced when in regular work; for, being low in silica, the newly blown-in furnace will be able to melt them easily and quickly, and so get a good start. As a rule the first slag contains about 30 per cent. of silica. When the last of the 100 blowing-in charges are in the furnace the regular charge is put on.

The following charges, with slags from same, together with the dip, sample assays, and mattes made, will give some idea of the usual composition of the smelting charges when in regular work. The last eight are selected because sulphide of lead was used in large quantities and no carbonate of lead ore.

Samples of Charges on Furnaces in lb. Nos. 1 to 8.

No.	Carb. Lead Ore.	Flue Dust.	Kaolin.	Silicious Lime-stone.	Crude Sul-phide	Iron Ore	Iron-stone.	Lime-stone.	Coke.
1	150	...	300	150	25	...	75	300	125
2	150	...	175	225	25	...	125	300	125
3	150	...	275	175	25	...	75	300	125
4	150	...	250	200	25	25	50	300	125
5	150	...	225	200	25	25	75	300	125
6	125	25	300	150	25	125	...	250	125
7	150	...	250	175	25	125	...	275	125
8	175	...	250	100	25	175	...	275	125

Leaving the coke out, these figures add to 1,000 lb. in each case; the weight and charge is always kept.

Slag analysis on morning following.

No.	Pb. %.	Ag. oz.	SiO_2 %.	Fe. %.	Mn. %.	Ca.O %	Zn. %.	Dip Assay, Silver oz.
1	2·25	4·2	42·0	12·7	12·8	17·1	...	586
2	4·00	1·4	36·8	10·2	14·0	15·2	...	340
3	2·5	3·4	45·2	9·4	7·0	......	...	520
4	2·75	1·4	46·8	10·2	6·2	......	...	436
5	2·25	2·7	39·6	14 0	8·0	14·7	...	484
6	1·50	1·6	40·8	9·6	10·0	......	...	220
7	4·5	2·6	38·0	10·0	11·0	......	...	292
8	4·25	1·8	39·4	10·5	10·8	......	...	277
9	1·5	0·6	34·5	15·2	7·8	17·4	5·0	68
10	3·5	1·0	28·5	19·5	7·0	18·4	5·8	86
11	3·25	1·2	34·8	15·4	7·8	......	5·2	74
12	1·75	0·9	34·0	14·0	7·9	18·8	5·2	80
13	3·0	0·6	31·6	20·8	7·0	12·4	6·6	134
14	6·5	1·4	29·6	23·4	6·0	9·5	5·6	92
15	1·5	0·9	32·5	15·0	8·2	19·8	5·3	78
16	1·25	0·4	34·2	16·4	7·1	......	5·4	116

Ore Charges, 9 to 16.

No.	Kaolin.	Silicious Iron.	Crude Sulphide.	Iron Ore.	Iron-stone.	Lime-stone.	Sulph. Concen.	Slag.	Coke.
9	125	175	325	...	150	225	...	100	125
10	125	125	325	...	250	175	...	100	125
11	100	150	...	50	...	225	425	100	125
12	125	175	325	...	150	225	...	100	125
13	125	125	...	...	250	175	325	100	125
14	125	125	325	...	250	175	...	100	125
15	125	175	325	...	150	275	...	100	125
16	100	150	....	...	100	225	425	100	125.

First Matte from Charges.

No.	9	10	11	12	13	14	15	16
Lead %	36·8	25·5	...	42·0	29·2	58·4	35·4	23·7
Copper %	4·2	4·4	...	4·2	6·2	3·2	4·0	4·4
Silver, oz.	42·0	29·0	...	41·0	52·0	35·8	33·0	31·0

Sample Assays of other Mattes.

Lead	39·7	33·7	31·3	32·8	34·4	43·2
Copper	29·6	25·3	27·3	29·2	28·4	22·0
Silver, oz.	195·00	244·00	138·00	163·00	172·00	182·00

Third Matte Assays.

Lead	29·8	32·9	37·9	37·1
Copper	40·0	42·2	35·2	32·7
Silver, oz.	326·00	361·00	179·00	261·00

The ironstone shown in these tables is distinct from the iron ore, the latter being the produce of the mine, analyses of which are given under the head of manganic iron ore, whilst the former was purchased at a cost of about 21s. a ton. It assayed from 6 to 14 per cent. silica and 50 to 60 per cent. of Fe.

The limestone came from Tarrawingee, and assayed from 6 to 11 per cent. silica, 1 to 5 per cent. of carbonate of magnesia, 1½ per cent. ferric oxide iron, the balance being carbonate of lime. It cost 14s. a ton landed on the mine.

Regarded as a smelting ore, the Proprietary ore was decidedly a nice one. Its composition, wherever the ore came from, was such a happy blending of bases and silica that it smelted very easily indeed, and had some means been provided by which the ore could have been regulated in its fluxing value as it went to the furnaces, as well as its silver and lead value, the mischief caused by irregular qualities of ore would, of course, have ceased, and allowed of clean smelting there as elsewhere.

The presence of manganese binoxide in the ore was also of the greatest assistance both as an oxidiser for the sulphur and for its rapid melting qualities. The zinc was never present in the slags in sufficient quantity to cause any mischief. Alumina was the greatest nuisance; and my experience has been that with slags up to about 36 per cent. in silica the alumina acted as a base; but usually as soon as this point was overstepped, the slags immediately thickened up and assumed a most silicious appearance, due,

in my opinion, to the alumina changing its functions from that of a base to an acid. It has been experienced so often on different ores as to leave no doubt in my mind that its action is as stated.

After a furnace has been at work for a day or two all trouble arising from the "blowing-in" operation is gone if care has been exercised. The "blowing-in" crust is some trouble if allowed to form; but as a rule it is great want of attention that allows this to make. It is due to the ashes of the wood which was thrown in at first to ignite the coke, forming into a solid mass, through the first slag formed chilling in it. The mischief of it is that it prevents the lead reduced or added to the "blowing-in" charges from getting into the well, and unless holes can be driven through it into the lead underneath, the latter will most assuredly chill and cause endless trouble, worry, and expense. When the furnace has been running slag for about an hour, the ashes inside can be broken up by introducing an inch round bar through either tap-hole and running it well into the furnace in all directions with the aid of seven or eight men. The ashes then float out with the slag, and if this is done fairly often for the first hour or two all danger of a "blowing-in" crust is avoided. The blast pressure is gradually risen to the point settled on, 10 to 15 oz. usually, and the temperature of the lead in the well soon increases until at the end of twenty-four hours it is usually bright-red. With good ore and plenty of water free from lime or magnesia, the furnace should have a long and successful run.

The largest output of lead that I know of from one furnace for twenty-four hours was 26 tons; 166 tons of charge being smelted to produce this. The ore smelted consisted of carbonate of lead averaging about 35 per cent. to 45 per cent., and was, of course, the easiest smelting ore to be had. This happened at the British Mine when I had charge of the furnaces. The week's output of lead at the same time was 167 tons. Carbonate lead ore is no longer found in any large quantities, and it is now carefully hoarded, so that if a furnace produces from 5 to 7 tons of lead a day it is quite equal to the average output.

COST OF SMELTING.

This varies from half-year to half-year; but, on the whole, has has steadily decreased, until at present it costs about 25s. a ton, including costs for superintendence, labour, repairs, water, fluxes, fuel, light, &c. In 1888 the cost of smelting amounted to 36s. 5d. per ton, with the pick of the ore to smelt. The costs given do not, of course, cover desilverisation expenses, insurance, carriage on bullion, &c., but are simply the actual expenses incurred on a ton of ore in the blast furnace department from the time the ore is received from the mine until the bullion is made and put in the railway trucks ready to be despatched for further treatment.

The lowest smelting cost per ton of ore was, I think, done at the British furnaces, on Proprietary ore, from the 1st of June, 1894, to the 13th September, 1894.

The quantities of ore smelted were as follows:—

Carb. lead ore	4,358	tons net.
Silicious iron and kaolin	16,395	,,
Manganic iron ore	5,279	,,
Sulphide ore...	53	,,
	26,085	net tons.

Coke used, 3,801 tons, or 14·57 per cent. on the ore; limestone used, 2,452 tons; coal used, 59 tons; firewood, equal to coal tons, 774 tons.

The total cost of everything, including rent, water, coke, flux, coal, firewood, repairs, stores, light, salaries, assay expenses, and labour about the furnaces, was £24,214 1s. 11d., or 18s. 6¾d. a ton on the net ore.

Manganic iron ore was good and plentiful, and, therefore, no ironstone had to be purchased, which, of course, materially helped toward the low cost of smelting.

This year will probably see the last smelting done in Broken Hill, the Proprietary Company finding it to their advantage to carry their ores to Port Pirie where coal, coke, and fluxes are cheaper than at Broken Hill, and also of better quality. Low rates of freight offered by the South Australian Government have been one of the inducements, and with cheap and good concentration of the sulphide ores, it costs less railage per unit of lead when in rich concentrates to send to Port Pirie than if it was first made into bullion. This is no inconsiderable item.

The advantage of concentrating the smelting operations and lead-refining under one Superintendent will also be gained, for hitherto the Company had six furnaces at Port Pirie in addition to those at Broken Hill, necessitating a separate staff in each place.

SMELTING LOSSES.

In the absence of any reliable method of sampling the ore, the exact contents were never really known. "Grab samples" were the only means used to arrive at its value, taken from each mine truck as it reached the surface, and at the furnaces a man was kept on each shift to sample the ore as it was smelted. It was the crudest method of sampling possible, and naturally the results were just as crude and useless. Had accurate means of sampling obtained, it would have been a great check on the furnaces and given the General Manager a lever which he never possessed on the whole metallurgical department. Certainly it would have saved many thousands of pounds yearly. Accurate accounts were

made out on the basis of the assays which were obtained from the samples, every little item being brought into account each week to the last fraction of a penny, to get at the cost per ton of ore treated. These latter were correct enough, but the statement of the recovery of the silver and lead was not worth the paper it was written on, inasmuch as the basis of the whole thing, the assay of the ore, was the result of incorrect sampling. The samples were just as likely to show a greater value in the ore than it contained, or *vice versâ*. Hence you would see that for one week the total extraction of lead was 70 per cent., silver, 120 per cent. The next week the figures would show a recovery of, lead, 47 per cent , silver, 65 per cent. These discrepancies can only be attributed to the incorrect method of sampling. Apparently more silver was recovered in the first instance than was in the ore, showing immediately the valuelessness of the whole return. A reliable statement of the extraction of silver and lead from Broken Hill furnaces generally is not to be obtained, but my opinion is that about 90 per cent. to 92 per cent. of silver and 65 per cent. to 70 per cent. of the lead actually in the ore were recovered in marketable products. The loss in slag was great, because the proportion of slag made to ore smelted was from $1\frac{1}{4}$ to $1\frac{1}{2}$ to 1, due to the silicious character of the ore. The average lead assay of the ore smelted in later years was not more than 15 per cent., and the average lead assay of the slags was about 4 per cent. If $1\frac{1}{4}$ tons of slag were made for each ton of ore smelted, the loss of lead must have been 5 units out of the 15 units of lead in the ore, or 33 per cent. Other losses of lead take place in fumes and escaping flue dust, but are not so extensive as has been assumed. The flue dust recovered is equal to from 0·80 per cent. to $1\frac{1}{2}$ per cent. on the weight of ore charged into the furnace.

The following determinations give some idea of its principal constituents :—

Flue Dust.

Lead, per cent.	25	37	23	30	30
Silver, oz.	20	24	30	21	21
Zinc, per cent.	11	13	10·8	10·7	10

The usual method adopted with this material is to moisten it with water and return it to the furnace. Necessarily a great percentage of it rapidly dries, and is carried out of the furnace by the strength of the blast back into the flues.

No particular effort has been made to make a better collection of the flue dust, the flues being designed simply to carry off the smoke and fumes, and accordingly the lighter particles of dust (and these are always rich in lead) are carried off by the force of the draught into the stack, and fall outside on the surrounding

land. Plenty of ore, of good value, has always enabled the company to pay good dividends, and the loss arising from escaping flue dust has not been felt.

Larger flues, with plenty of impediments to check the current in the shape of baffle walls, would certainly have cost a considerable sum, and in the position in which the furnaces stood would have been almost impossible to build; but had the furnaces been better placed to allow of long flues being built, the latter would have paid for themselves long ago, besides preventing the distribution of an undesirable substance on the land. Vegetation was not damaged by it, for the simple reason that there was none to damage, and it is doubtful if the general health of the town suffered in any degree.

REFINING OF THE BULLION.

Although this was not carried on in Broken Hill, still it is so closely associated with the ore treatment that it might be well to give a short description of the work. The refinery is situated at Port Pirie, in South Australia, on the sea coast. The spot was chosen as being about the most convenient place, having a water traffic for the largest ships; in the centre of a good flux district, and with its sea advantages, coal, coke, and stores were landed at a price very considerably below the cost in Broken Hill. The last year or so the company have found it to their advantage to refine the whole of their output of lead due to the extortionate charges and deductions made by English refiners. The plant is capable of handling some 800 tons of silver-lead bullion weekly, and is very complete in detail. It was designed by Mr. H. H. Schlapp.

THE PROCESS.

The silver-lead bullion is first put into 50-ton reverberatory furnaces, where it is melted down slowly, so that as much of the impurities which it contains may be taken out at the commencement. This impurity or dross, as it is styled, consists almost entirely of an alloy of copper and lead with silver, one part of copper taking up sixteen to seventeen parts of lead. When the lead is all melted down the layer of dross is skimmed off clean. The heat is then raised, and by degrees the small percentages of copper, antimony, iron, sulphur, &c., are skimmed off, leaving in the furnace a soft, easily-marked lead and silver bullion. This operation takes some twelve or more hours to finish. From the furnace it is tapped into cast-steel kettles of 30 tons capacity. By the aid of a fire under the kettle the lead is made red-hot, and a small percentage of metallic zinc, from about $1\frac{1}{2}$ per cent. by weight downwards, is added. This is well stirred in for some half hour or longer, and then the contents of the kettle are allowed to cool down considerably. As soon as the

temperature falls below a certain point, the zinc, which has alloyed with the bulk of the gold present some silver and lead, begins to separate out exactly as cream rises on a dish of milk, and is skimmed off and kept for further treatment. The remaining lead and silver are then heated up to redness once more, and about 1½ per cent. of zinc added. The cooling process is repeated, and the zinc-silver-lead crust once again skimmed off. This "skimming" or "crust," known as the "silver crust," in contradistinction to the first one, called the "gold crust," is kept apart from the latter. The zincing operation may have to be repeated once or twice before the lead is desilverised; usually half an ounce left in is considered low enough. It is then siphoned off into a lower kettle by means of a Steitz siphon, made of ordinary 1¼ or 2 inch black iron pipe. This lower kettle has a movable hood; and as soon as the temperature of the lead has been raised sufficiently dry steam is forced into the lead to oxidise the zinc which has remained in from the preceding operation of zincing, and also to remove the last traces of impurities. When the lead which contains the zinc is heated to redness it has the power of decomposing the steam, the zinc and some lead seizing on the oxygen of the steam to form oxides of their metals. These oxides gather on the surface of the lead and are skimmed off occasionally. Samples of the lead are taken from time to time, and the purity of the lead is judged by its colour and the ease with which it can be marked. Good soft lead is easily marked with the finger-nail.

As soon as it is decided that the lead is purified, it is skimmed quite clean with wooden rakes, and then allowed to cool considerably, so that when it is cast into moulds it will set even, and be of a silvery-white colour. Moulded at a greater temperature a bluish appearance is assumed by the lead, due, probably, to a film of oxide forming. When cool enough it is syphoned off into moulds, and then is ready for sale in the market as "best refined lead." The Proprietary refined lead is remarkably good, and commands as good if not a better price than the English refined lead. This is due in great degree to the small amount of impurity which the original bullion contained, and, secondly, to the care evidenced throughout the refining process.

We have now to deal with the dross which was obtained at the commencement of the process. This is either sent direct to the blast furnaces to be smelted up with the charge, or else it is put into the liquating or sweating furnaces, where it is heated gently to expel any metallic lead which has clung to the actual dross. This lead runs out of the furnace into an outside kettle, separately fired, to keep the lead obtained in a molten state, and when enough has gathered it is moulded into bars, and returned with the next charge to the softening furnace. The dry liquated dross is then smelted in the blast furnaces with the ordinary ore charge.

The zinc-silver-lead crusts obtained from the second zincing of the softened lead in the kettle are also liquated to free them from any lead which they may have gathered, and the lead liquated out is returned to the zinc kettle. The dry product left behind is put into graphite and clay retorts with a percentage of carbon, and highly heated. The zinc distils off, and some 50 to 60 per cent. of it is recovered in metallic form in the retort condenser, the balance being recovered as an oxide known as "blue powder," some being lost in fume. As soon as the retorting operation is finished, which takes twelve to fifteen hours, the zinc condenser is removed, and the rich silver-lead bullion, of some 5,000 oz. to the ton, is ladled out into moulds. The style of furnace is a modification of the Latham retort furnace, and is not so handy as the Du-Faur tilting retort furnace, which pours out the lead instead of having it ladled out. The retort is thoroughly cleaned, care being used because the heat has softened it considerably, and, after cleaning, some carbon in the form of charcoal is thrown in to keep the little lead left in the retort from forming litharge, which would rapidly destroy the retort. The latter is then ready for a fresh charge of the zinc-silver-lead crust. A retort lasts from twelve to thirty charges, and then is replaced by a new one.

The rich lead bullion obtained from the retort is then taken to the refining or cupelling furnace. Here it is melted into a test or cupel (made of fire-clay, cement, and ground limestone, beaten in with a rammer into a cast-iron supporting-frame, being allowed four or five weeks to dry before being used), and as soon as the lead is hot enough an air blast is turned on to the face of the bright red lead, and the operation of refining for silver commences. The action of the air is to oxidise the metallic lead into litharge, and this flows off in a stream more or less high with silver. As the level of the charge falls, fresh bullion is fed in through a small hole, but when the charge is almost pure silver, and the cupel quite full, this is stopped. At the finishing part of the cupellation, the most beautiful iridescent colours traverse the face of the silver, due to the last traces of lead passing off. The temperature of the furnace has to be kept very high to keep the mass of silver molten. As the last signs of lead disappear the process is finished. The molten silver is then poured into moulds or granulated in water, and finally refined in large crucibles with nitrate of soda or potash, from whence it is poured into moulds holding about 1,000 oz. of fine silver each. The grade of the silver is about 996 fine, the remaining four parts usually consist of copper with the very smallest trace of lead.

The gold silver-lead-zinc crust got in the first operation of zincing in the first kettle, goes through exactly the same process as does the second crust just described. After it is made into bars it is, however, further treated for the separation of the gold and

silver. The bars of this Dore silver, as it is called, are put into a cast-iron kettle heated by a fire, filled with strong sulphuric acid, preferably of about 66° Baumè. This is boiled until complete solution of the silver takes place, the gold being left as a dense, black, finely-divided powder at the bottom of the kettle. The solution containing the silver is either ladled or siphoned out of the dissolving kettle into a settling tank warmed by steam passing through a leaden coil. Here any fine particles of gold which may not have settled in the dissolving kettle are collected. The silver solution is diluted to about 24° Baumè, and emptied into a precipitation vat in which plates of copper are arranged. The reaction between the metallic copper and the silver sulphate solution causes the silver to precipitate and the copper to go into solution as a sulphate, so replacing the silver. The liquor left in the vat after the silver is all out, is siphoned into vats, where the copper sulphate is crystallised out. The silver precipitated on the copper plates is then taken to a vat and well washed in hot water to free it from the last trace of sulphate of copper. It is then melted up and sold as fine silver, and is about 997 fine.

The gold is sometimes pure enough to melt up into bars, but if not it is boiled with fresh acid; then thoroughly washed, dried, and melted. Since this method has been adopted, the "Mœbius" electrolytic separation of gold and silver has come into prominence in America, and some writers claim for this process that the cost of separation does not exceed one-eighth of a halfpenny per ounce.

CHLORIDISING AND LIXIVIATION.

The ore which is handled in these portions of the works is too low grade to pay the expense of blast-furnace treatment, and it has to be mined to get at the other and richer ores; so there is a choice of two things, either use it for filling the stopes or treat it at a small profit. To get this small profit the chloridising and lixiviation works have been erected. The first part of this plant consists of the necessary crushing and power machinery for reducing the ore to the required state of fineness. Salt is added during the crushing operation from 4½ to 6½ per cent., by weight. The mixture of crushed ore and salt is elevated into hoppers, from which the ore is automatically fed into a series of eight Howell Revolving Cylinder Furnaces, which chloridise from 30 to 40 tons of ore per furnace daily. All of the furnaces are not in constant work, some always being kept as stand-by furnaces, ready for use at any time. These furnaces automatically deliver the chloridised ore into trucks, which are picked up by a revolving steam crane, the ore being dumped out to cool on a large open floor.

The quantity of ore treated weekly averages from 1,400 to 1,500 tons, at a cost for all expenses, such as superintendence, coal,

labour, salt, repairs, assay expenses, water, light, stores, &c., of 12s. to 13s. a ton on the gross ore crushed.

The following analysis of the chloridised ore may be of interest:—

	1	2
Silica ...	78·40 ℔ cent.	78·00 ℔ cent.
$PbCl_2$ ...	3·76 ,,	5·37 ,,
Ag Cl ...	·042 ,,	·044 ,,
Na Cl ...	2·48 ,,	6·20 ,,
Fe_2O_3 ...	8·62 ,,	9·00 ,,
Al_2O_3 ...	0·14 ,,	0·15 ,,
MnO_2 ...	5·07 ,,	2·55 ,,
ZnO ...	1·25 ,,	2·18 ,,
		Trace of Antimony.
	99·762	99·894

From the cooling floors the chloridised ore is hauled to the lixiviating works and there dropped into leaching vats, of which there are 12, arranged in two rows, with footways between them and tramways over them. Each vat is circular, made of 3-inch thick timbers, the bottom timbers being tongued and grooved and the sides simply butt joints, the whole stayed with wrought-iron straps passing around the vats. The diameter is 16 feet and the depth 7 feet, and with a 5-inch false or filter bottom, made of rough cobble stones about 4-inch ring size, covered with a layer of straw. The vats are filled up within about 12 to 15 inches of the top, and hold about 49 to 50 tons of the roasted ore.

The vat of ore is first washed with hot water at the rate of 16 inches an hour for one and a half to two hours. This dissolves out a very considerable quantity of the lead chloride and salt in the ore. The wash-water runs into depositing pits outside the building, where the metallic contents are precipitated by scrap-iron, the after liquor running to waste.

After washing, a 1 per cent. solution of sodium hyposulphite is run on the ore, and of a temperature as nearly as possible about 100° Fahrenheit. The speed of the leaching is from 4 to 6 inches per hour, and it usually takes forty to fifty hours to finish a vat. Ten hours after the leaching liquor is put on; 360 ℔. of carbonate of soda are put on to the top of the ore under the stream of hyposulphite of soda, which dissolves it up. This is added for the reason that the lead chloride not extracted by the first wash-water attacks the solution of hyposulphite of sodium, decomposing portions of it, and forming lead hyposulphite. If carbonate of soda is added to the hyposolution, it, in turn, decomposes the lead hyposulphite and forms carbonate of lead, and regenerates the

hyposulpite of soda before destroyed. Lead carbonate being insoluble in hyposolution is not again attacked. It was found that about ten hours after the hyposulphite solution was run on the ore was the best time to put in the carbonate of soda. Some experimenting took place to determine the proper hour, and it was found that the best silver extraction results were obtained if this rule was maintained.

The solution of hyposulphite of soda, with silver and lead in it, is conducted into one of a series of circular precipitating vats, each 10 feet diameter and 9 feet deep. When the vat is full, the lead in solution is precipitated by a saturated solution of carbonate of soda, using phenol for the alkaline reaction, which is taken as a sign that the lead is all precipitated. Some silver goes down with the lead, so that the precipitated carbonate of lead usually assayed about 70 oz. of silver per ton. The liquor, with the precipitate in suspension, was blown with compressed air for twenty minutes or thereabouts, the precipitate settling very rapidly afterwards. When the supernatant liquor was quite clear, it was drawn off into one of a series of six vats of the same size as the lead precipitating vats. Here the silver was precipitated out by sulphide of sodium, and on settling, the clear liquid was run through a sand filter and elevated back to the hyposulphite tanks in the top of the building ready for use again on fresh vats of ore.

The sludge of carbonate of lead was run into two storage vats, each 10 feet x 7 feet, and from these was sucked into a boiler-iron pressure-tank with a vacuum created by a steam ejector. When the tank was full the suction tube was closed, the steam ejector stopped, and a tap opened, which admitted compressed air, so forcing the semi-liquid sludge into a Johnson filter-press at a pressure of 60 ℔. to the square inch. The liquor from this press was returned to the silver precipitating vats, and there treated, The dry cakes of carbonate of lead, obtained from the filter press, were sent to the blast furnaces for further treatment.

The silver sulphide was filter-pressed in similar manner from storage tanks, 7 feet 9 inches diameter by 5 feet 9 inches deep, and the dry cakes roasted and melted with poor lead to make a rich bullion.

The roasted ore handled was equal to about 1,000 or 1,100 tons weekly, and the average apparent extraction of silver was about 79 per cent.; the real extraction, after taking into consideration the 6½ per cent. solubility of the ore, was 80¼ per cent. The roasted ore treated averaged between 12 to 14 oz. per ton of raw ore. The total cost of leaching, counted on the raw ore originally crushed at the chloridising plant, amounted to about 6s. 9d. per ton for all costs, including chemicals, labour, superintendence, water, light, stores, repairs, renewals, coal, scrap-iron, &c. The water consumed cost about 4s. per 1,000 gallons;

and, roughly, 100 gallons were used for each ton of ore roasted. The cost of chemicals made up 2s. 6½d. per ton of the total cost.

The sodium sulphide was prepared in the works, being made of two parts caustic soda and one of sulphur, boiled with steam to assist chemical union.

The following represents approximately where the silver was recovered in the different operations performed in the leaching department :—

In the sulphide precipitate	... 75·78	per cent.	of the whole.
,, carbonate of lead	... 6·31	,,	,,
,, wash-water ...	... 16·44	,,	,,
,, vat bottoms ...	... 1·47	,,	,,
	100·00		

The total men employed in the leaching works were as follows for each day of twenty-four hours :—

3 chemical mixers.
3 ore-vat men.
9 men at filter presses.
3 precipitating men.
3 shift bosses.
20 men removing leached ore.

Total ... 41 men.

Salt cost 36s. 8d. a ton; coal, 34s.; and wood, 14s. a ton. The plant cost, on completion, a little over £15,000.

The Russell extra solution was used some years ago, but no apparent benefit was obtained by its use, and it has been discontinued since about 1893. Taking the hyposulphite process, as a whole, it has not been very successful, due to the character of the ore and the particular form the silver is found combined in. Usually the latter consists of native silver, iodides, and chlorobromides. I do not think pure silver chloride exists in Broken Hill ores. Until the chloridising furnaces were built, the process had given rather disappointing results. Better results were obtained when these furnaces began to work; but then the percentage of lead began to rise in the available ores. The carbonate of soda addition to the vat seems to have conquered all difficulties until fresh ones turn up.

Of all the bye-products made from the leaching plant, that from the wash-water precipitate has been the most troublesome. As the hot wash-water cools, it deposits chloride of lead that is not wholly decomposed by the iron scraps, and, when the precipitate from the tanks is cleaned up and sent to the smelting plant, heavy losses in volatilised chloride of lead is experienced. The most

satisfactory solution of the difficulty is adding oxide of lime to the solution and precipitating the lead and silver in that way as oxide; the bye-product of chloride of calcium can be let go to waste. It is a matter of expense only, for the reactions are perfectly satisfactory.

AMALGAMATION.

This process was discontinued some twelve months ago. The extraction of silver was very satisfactory, but the specific gravity of the ore was high enough to always interfere with the separation of the mercury in the settling pans, and you would see masses of manganic iron slime that were full of mercury in the finest state of division—of course carrying silver—with which nothing could be done, economically, to extract the locked-up mercury. It soon resolved itself into a matter of the cost of mercury; but, if an ore of about 20 to 22 oz. of silver had been obtained steadily for the amalgamation work, there was no doubt of its superiority to the leaching plant; because the loss remained the same, whether on 14 oz. or on 20 oz. ore, a rule which did not act so well with the leaching. As the grade of ore necessary, low in lead, could not be obtained in large enough quantities to keep the whole of the plant going, it was stopped. Its capacity was about 1,000 tons weekly. There were 60 stamps erected, with a drop of 6 inches, weighing 850 lb. each, and 95 drops a minute. The remainder of the plant consisted of 24 grinding and 24 Howell amalgamating pans, each 4 feet 6 inches in diameter and 3 feet 4 inches deep—the first-named pans running 40 revolutions a minute, and the latter 75 to 80 revolutions. There were also 12 settling pans, running 14 revolutions a minute, each being 8 feet in diameter and 3 feet 6 inches deep, the whole of the pans being cast-iron.

Towards the latter end of the operations it was found that bluestone (sulphate of copper) was not necessary for the successful extraction of the silver in the amalgamating pans; and it was not an uncommon thing to have the retorted bullion from this plant, after the use of the blue-stone stopped, running 996 to 999 fine in silver.

CONCENTRATION.

The first attempts at concentration were made on the low-grade carbonate ores. The evil day of sulphide treatment had not yet come. The ore sent to the concentration department was highly silicious, low in lead and silver; and if the ore had been specially mined for the purpose of concentrating it, there is no necessity to hesitate over the fact that it was not a payable proposition. But, like the low-grade ores which are chloridised and leached, this ore had to be taken out, whatever use was made of it afterwards. The cost of mining it was borne by the smelting ore necessarily, and placing the matter on a common, ordinary, bookkeeping footing

this low-grade stuff cost nothing delivered on the surface. Its value ran from 7 to 12 per cent. lead and from 6 to 14 oz. of silver; and the question was: Could this low-grade material be concentrated at a profit? Without further treatment the ore was worthless; but the carbonate concentrate that was produced from the ore was infinitely preferable to use in the furnaces than the crude sulphide ores. Looked at in these days, when carbonate ore high in lead is getting to be worth more than the value of its metallic contents, there would be no hesitation as to what would be done with the low-grade ore; but in those days, when lead ore in the carbonate form was plentiful, when the value of a ton of lead in Broken Hill was but 50 per cent. of its London market price, the wisdom of some of the immense concentration plants which were erected seems doubtful. Block 14, the British Company, and the Proprietary, rushed into enormous expenditure; whereas one only of the first concentration plants erected would have demonstrated for evermore their uselessness on the class of ore that had to be treated.

The first system of concentration was with the Collom jig, and after, treatment to recover the rich slimes by a kind of Linkenbach table. The ore was first crushed with an enormous steam-eating stamp—the very worst system of crushing which could have been devised for this class of ore. Think, for a moment, of the composition of the ore—a hard quartz and a friable carbonate of lead. Every blow of the stamp shattered the quartz into fragments—of that there could be no doubt; but it smashed the bulk of the carbonate of lead into slimes. The stamp was something like the whole plant—there was no economy in the structure of either, and when finished neither did the work expected of them. Both the stamp and the jig were splendid appliances for dealing with ore like they have at Lake Superior, U.S.A., from whence they were imported, where the ores were copper, the latter existing almost, if not altogether, in the metallic form. No smashing blows could do any mischief on this class of material, and the large crushing capacity of the steam stamp was thus an advantage.

Time went on, and the steam stamp was thrown out on the scrap heap, and a good many of the Collom jigs also. Alterations were made in their motions, notably at the British Mine, where the tappet motion of the plunger was altered and driven with an eccentric, so giving a more even pulsation in the jig. This improvement was a good one; and if the size of the jigs had been about three times greater, considerably better recovery would have been made; for, after all, the Collom jig, as used in Broken Hill, was but a toy. As the carbonate ores began to disappear, the attention of the mine managers was impelled to the sulphide problem, of which volumes have been, and no doubt will yet be, written.

The first attempt to concentrate the crude sulphide ores was, I believe, made at the British Mine, and it was an unqualified failure so far as the commercial side of the question was concerned. Constant trials were made at the Proprietary Mine with varying success; but it is safe to say that until the Hancock jig was introduced at Block 14, all the efforts at profitable concentration of the low-grade sulphide ores were unmistakable failures. Lessons had been learned by the various companies regarding expenditures on concentration schemes, and they all waited until Block 14 had demonstrated that something could be done with this jig. Then the South Mine installed them, and then the British Company.

The recovery of the first jigs did not amount to more than 48 to 54 per cent. of the lead; but in spite of the low recovery the size of the jig allowed large quantities of ore to be rushed through them at the minimum of cost. As soon as it was found that some profit could be made out of the hitherto hopeless sulphide ore, even with such an extravagant loss of lead, more attention began to be paid to the re-treatment of material rejected from the last hutches. These were crushed finer and passed through a second jig, and the same process was gone through with the low-grade product of the hutches of this jig, passing it through a third jig; so that with the addition of slime buddles something like 65 per cent. to 75 per cent. of the lead contents of the ore treated is now recovered from the crude ore. The crushing machinery adopted for the ore with these jigs is the ordinary jaw-crusher, on the old Cornish principle, with a set of Cornish rollers for finer pulverisation.

A new jig which is bearing the test of work and competition against the Hancock jig is that known as the "Warren and May's Improved Double Plunger Jig." These jigs are working on a large scale at the Block 10 Mine, Broken Hill, and have been adopted by the Junction Company. The Proprietary also decided to adopt them after most careful tests against the Hancock jig. The following is a description of the Warren jig:—

The ore is crushed to pass through a trommel, pierced with a rectangular slot 16 gauge wide and a bare quarter of an inch in length. From the trommel the crushed ore drops into the receiver with a perforated bottom, through which it passes into a Warren patent slime separator. This separator is a revolving basin or pan with an adjustable overflow in the centre. The water, with the slime in suspension, passes down the centre while the ore drops to the bottom of the pan and is wiped out by a volute-shaped plate, comparatively free from slime or water, over a lip, into the sleeves of the jigs. The plungers are connected by a rod with a rocker, the length of the stroke given to the plunger being regulated by a pin, which may be moved in or out along the slot in

the rocker by a handwheel and screw. The rockers are actuated by a lever, which is connected by a rod to an adjustable pin in the disc, which is driven by a belt pulley. The belt wheel drives the shaft, on which is placed a small disc with an adjustable pin in it, to which is attached a rod. One end of this rod is connected with the lever which drives the tapping shafts, and by the aid of a ratchet and pawl these shafts are made to rotate very slowly, lifting by the cam a rod at the bottom end of which is attached a pear-shaped valve or plug. This motion allows the concentrates to pass out through an aperture and on to the proper receptacles for this product. By this means the interior compartments of the hutch are always kept clear; the products of the first three compartments are generally sufficiently high grade to sell, while those from the next two compartments are, by the aid of an elevator, returned to the machine again, the sixth compartment being the tailing receptacle. These are drawn off through a tap, with as little water as possible. The separator pans are driven with a pair of mitre wheels. The jigs are 22 feet long by 9 feet 3 inches wide and 4 feet 6 inches deep. The sides and ends are built of 3 inch Oregon, and the jigs stand on three trestles, made of 8 inch by 8 inch Oregon, of which two are 11 feet high, with a cast-iron girder on the top to carry the gear. A platform 2 feet wide runs along the two sides and tail of the jig. The waste water, when the machines are in motion, passes from the tailings' boxes, through the apertures, on to the plungers again, thus keeping up a perfect circulation within the jig.

The capacity of these jigs is given at 8 tons of crude ore per hour. It is stated that 75 per cent. to 80 per cent. of the lead contents of the crude ore is recovered by the Block 10 concentration plant, which is certainly the best work that is known yet. The plant is capable of treating over 2,000 tons of crude ore weekly.

The assays of the crude sulphide of lead given earlier are about the average value of most of the sulphide ores which are being concentrated, if we except the South Mine which is higher in lead and lower in zinc and silver.

Costs vary with the different plants, and from 4s. 6d. to 7s. 6d. a ton on the crude ore are about the limits between which the costs at the different works lie. The recovery of the silver is the weak point in the concentrating process in Broken Hill, seldom more than 40 per cent. of the silver contents being recovered in the lead concentrate. The reason is, the zinc blende in the ore contains about an equal bulk of the silver, and the more successful the concentration to get rid of the zinc the more successfully the silver is removed also. I think close investigation will show that this estimate of the distribution of the silver in the ore is a fairly accurate one, but it would be interesting to have more information on the subject. Hence, in all the concentration plants at work in

Broken Hill a difficultly marketable bye-product of zinc tailings is produced, running high in zinc and silver (up to 40 per cent. zinc, and 25 to 35 oz. of silver per ton). The higher grades of this particular material are produced at Block 10, and they are content to accept as low as 10s. per ton for this product when a buyer is to be found.

ZINC RECOVERY.

No effort has been made until very late times in Australia to recover the zinc from the ore, either directly or from the bye-products of the zinc tailings. The Ashcroft process for the recovery of zinc has now been at work some time, but so far no results have been published as to its success or otherwise. The process this company originally started with was an electrolytic one. The ore was to be roasted and then leached with ferric chloride, oxide of iron depositing with the residual ore and a zinc chloride being produced. This, on purification from any gold, silver, or copper dissolved, was then subjected to the electric current in vats, the anodes being iron and the cathodes zinc. The idea was to regenerate the ferric chloride again; but it is said that some difficulty has been experienced in making the cycle of operations act properly—in fact, that the chlorine, instead of being all liberated as hydrochloric acid, and therefore in a condition to act on the iron anodes, is liberated as free chlorine and is lost. The amount of manganese in the ore, and which goes in solution on leaching the roasted ore with the ferric chloride, is also said to have interfered considerably with the deposition of the zinc, more especially after the leaching solution has got somewhat charged with the salt of this metal. By their latest reports, however, they claim to have overcome all the difficulties which have delayed them in the past, and we may hope to hear in the near future of the results of their efforts. It takes but half an eye to see how important to the mining industry at Broken Hill if some zinc recovery process be made commercially, as well as chemically, successful. The chief ore supplies which the mines now have left are, apparently, unlimited supplies of zincose lead sulphide, and there is no doubt of the effect a good process for zinc would have on the prosperity of the whole of the sulphide mines.

Other attempts have been made to recover the zinc, amongst which is an ammonia process, brought out by Mr. Carmichael, late of Block 10 and now of the Proprietary. This is based on the following reaction:—

1. $ZnO + (NH_4)_2SO_4 = ZnSO_4 + 2NH_2 + H_2O$

and

2. $ZnSO_4 + 2NH_3 + H_2O = ZnO + (NH_4)_2SO_4$

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A short description of the process is as follows :—The ore is first finely ground and roasted, to leave as much of the zinc as possible in the state of the soluble sulphate. It is then placed in iron retorts and heated with sulphate of ammonia to complete this part of the process and bring about the first reaction given. The ammonia distils off through a pipe leading from the end of the retort, and dips below the surface of a solution of zinc sulphate obtained by leaching with water ore which has been subjected to the retort treatment. The second reaction

$$ZnSO_4 + 2NH_3 + H_2O = ZnO + (NH_4)_2 SO_4.$$

is then obtained. The precipitated zinc oxide is filter-pressed out, and the filtrate of dilute regenerated sulphate of ammonia has then to be evaporated and crystallised out ready for use again.

Like all ammonia processes, the extreme difficulty of making the joints in the various parts tight, when free ammonia is present, has been, in this process, the stumbling block. It is now stated that this difficulty has been overcome, and, if so, we may soon hear of oxide of zinc being prepared by the Proprietary Company from their ores. The process is a beautiful one in its chemical reactions, but hitherto the loss of ammonia has been prohibitive of its use.

Other oxide processes are the magnesite and the calcium chloride processes, both owned by the Smelting Company of Australia ; but so far no attempts have been made to start work with them on a large scale. This company also owns the Siemens-Halske electrolytic process for the production of metallic zinc. The solvent used with this process to extract the zinc from the roasted ore is either sulphuric acid or sulphate of iron and alumina, or sulphate of alumina alone. There is no doubt that sulphate of iron would act as a good solvent for the zinc, and, unlike the leaching solution of the Ashcroft process, all of them could be regenerated with no loss, except leakage from pipes and waste of that kind.

I am trenching on the delicate ground of the problem of the sulphide ores, and therefore will say no more on the zinc recovery processes; but before leaving the subject I may be permitted to hope that so vast a field will continue to find workers, and that in time the just reward of their efforts will be obtained, and the wealth of the immense sulphide mines of Broken Hill be brought within reach.

No. 5.—THE RUSSELL PROCESS (OF SILVER LIXIVIATION) IN AUSTRALIA.

By Edgar Hall, and Edward S. Simpson, B.E.

(Read Saturday, January 8, 1898.*)*

Part I.—By Edgar Hall.

The improvements in the treatment of silver ores by the hyposulphite lixiviation method, introduced by E. H. Russell in 1884, and known as "The Russell Process," gave rise to hopes, not only in the minds of the inventor and his associates, but also in the mind of nearly every chemist who ever performed any preliminary tests of ore by Russell's methods, that it would prove of widespread usefulness. Those hopes have not been realised, and to-day the process is at work in only two large establishments, where, however, it is an unqualified success.

During the interval since its introduction many papers have been written on the subject; one treatise has been published with special reference to it; and an enormous number of comparative experiments bearing upon its various features have been performed and published. The process has been practically applied in many places where large works, now silent, have been erected, by which many thousands of tons of ore have been treated successfully. Probably no metallurgical process has ever been placed before the public so openly and frankly, and with such a wealth of data of all kinds. The reasons why the early hopes for the widespread future usefulness of the process have not been realised, in spite of its undoubted merits, are interesting. At bottom they are due to the immense advances which have been made in metallurgical science and practice, whereby the precious metals have been brought within the smelter's scope, and their extraction from alloys and mixed products rendered cheap and easy.

In the first place the Russell process was introduced as an improvement upon the amalgamation methods, and its advantages were all advantages as compared with amalgamation. Russell was chemist at an amalgamation mill when he worked out his process Ores suitable for amalgamation were those suitable for lixiviation and but few ores unsuited for the former can be treated by any wet method. Both systems require ores but slightly mineralised by other than precious metals, they must be oxidised or contain but a small amount of sulphur, and they both need a preliminary roasting with salt to chloridize the silver. Such ores are of comparative scarcity in large quantities, and when found are rapidly

exhausted. Up to this point the defects of the Russell process are the defects of amalgamation also; and if the Russell process has failed to extend, so has the amalgamation process, and for the same reasons. Both fail to extract anything but gold and silver, and both require a generally expensive chloridizing roasting, which causes a loss of silver amounting to at least 8 per cent. of the total contents, which loss by unskilful work is largely increased. This heavy preliminary loss far exceeds the total loss at a good smelter, and alone is a heavy handicap. At amalgamation mills this loss was formerly neglected or denied altogether, and it seems impossible to lessen it materially. From this point onward the advantages are all on the side of the Russell process, especially since the refining of the sulphide precipitates by the Dewey process has been so successful. Had the conditions remained favourable to the extension of amalgamation, it is safe to assume that Russell's process would have fulfilled the early hopes of its supporters; but the improvements in smelting, and the increased cheapness of transit to large smelters where ores of all kinds make self-fluxing mixtures, have lowered smelting charges to a point which leaves small opening for other processes. The Russell process, like most others, cannot compete with smelting at equal prices.

In places where siliceous silver ores carrying no other metal of value occur far from railroad facilities, the Russell process will still hold its own, and its results can be calculated with certainty beforehand. Compared with the older lixiviation processes, Russell's is in the direction of greater efficiency, and the adoption of his improvements is simply a question of relative economy. The great fall in the price of silver lessens the value of his extra solution, but the ore must be indeed of low grade when its use costs more than its return. Where the ores to be treated contain blende, even in small quantities, and the roasting is done in mechanical furnaces, the use of the extra solution becomes imperative, owing to the reducing action of the unaltered zinc sulphide on the chloride of silver formed in roasting, as soon as leaching begins.

The history of the process in Australia is short.

Mr. T. G. Davey, then metallurgist at the Boorook Silver-mines, was the first to experiment with the process in this country.

At an early date that gentleman did some large-scale experiments upon ore obtained from the newly discovered Webb's Silver-mine, near Emmaville, and as a result of those experiments, and upon his recommendation, a plant was erected there to use the process. Mr. Davey directed operations at first, but was superseded by gentlemen from America, who were supposed to have special knowledge of lixiviation. None of these gentlemen carried the process to a successful issue financially, and ultimately the plant was dismantled and sold. Mr. Davey states that the process was a success from a metallurgical point of view, an extraction of 90 per cent.

having been obtained, and that the failure was due to defective mechanical arrangements and to lack of ore. No detailed results were ever made public.

The ore at the Webb's Mine consisted principally of argentiferous fahlerz in a gangue of quartz-veined slate ; the fahlerz contains a good deal of copper and antimony.

An extensive lixiviation plant was erected at the Broken Hill Proprietary mine some years ago, and is still working. The writer has failed to obtain any information about the working of this plant beyond a statement from the secretary of the company to the effect that the Russell process was tried and found to be of no value to them. The nature of the material treated (tailings from the concentration of lead carbonate ores), and its extremely low grade (the accounts for over five years show an average of only 8½ oz. per ton), render this very probable.

In 1891 the writer did some experimental work with the process on the silver ores of Rivertree, which led later on to the erection of a plant to treat the ores on that field. The results of the experiments were published in a pamphlet printed at Brisbane in August of that year. The mill subsequently erected underwent many vicissitudes, and is now partly dismantled, the ore supply having failed utterly to come up to expectations as regards quantity.

During 1895 experiments on a large scale with the Russell process were made at the White Rock Mine, at Drake, New South Wales, which were successful, and a large lixiviation plant is now being erected at that mine. It is with the results obtained at the mill erected at Rivertree that this paper will deal. Although siliceous ores of silver have not yet been found in large quantities in Australia, the possibility of finding such ores remains, and our conditions are such that it is probable the discovery will be made in country where a cheap method of reduction on the spot will be needed. The writer hopes, therefore, that a record of the work at Rivertree may yet be of value to some Australian metallurgist.

The silver lodes of Rivertree, New South Wales, occur in a granite formation, which is overlain by beds of altered shales of Devonian age, and is penetrated by dykes of diorite and quartz-porphyry.

The mineral-bearing belt is about 3 miles long and 2 miles wide, and contains numerous veins of quartz which carry silver. The veins are very small, few averaging 6 inches in thickness for many feet, and the ore shoots are not continuous in either length or depth. The ore, when clean and free from gangue, is generally quite rich, and consists of quartz-carrying galena, fahlerz, blende, pyrite, and arseno-pyrite, with proustite in microscopic crystals. The veins are oxidised to very shallow depths and only so far as the granite is decomposed. When the unaltered granite is reached, the veins become smaller and poorer and no longer pay. In a

few instances lodes pass from the granite into the shales above, and become richer and larger and less siliceous. The most productive lodes worked hitherto occur at the contact of the diorite dykes with the shales.

The plant erected at Rivertree was designed by the writer and built under the superintendence of Mr. T. Eyre in 1892.

Advantage was taken of the fall of the ground to arrange it in three divisions :—

I. Rockbreaker and sampler.
II. Crushing and roasting mill.
III. Leaching mill.

I. The first division was placed near the mine, and comprised :—

1. Ore receiving bins.
2. Giant rockbreaker (Blake type), 15 in. x 9 in., driven by a 10 h.-p. Junior Westinghouse engine.
3. Crushed ore bins beneath the rockbreaker.

Immediately beneath the rockbreaker jaws, an automatic sampler, driven from the rockbreaker shaft, was fixed, which diverted at intervals the whole stream of ore to a sampling floor. About 5 per cent. of the ore was so diverted. The rockbreaker jaws were set to open 1 inch only at the bottom. The whole of the ore passed through the rockbreaker. From the bins beneath the rockbreaker and sampler the crushed ore was taken by tramway to the drying floor in Division II.

II. The crushing and roasting mill comprised :—

1. The drying floor.
2. One pair Wall's corrugated rolls.
3. One pair smooth-faced rolls.
4. Two revolving screens.
5. Two elevators.
6. Fine-ore bins.
7. White-Howell roaster.
8. Cooling floor.
9. 35 h.-p. standard Westinghouse engine.
10. 52 h.-p. Babcock and Wilcox steam boiler.

The drying floor (30 feet x 24 feet) was formed of cast-iron plates over flues, which acted also as dust chambers for the roaster. The roaster was 25 feet long by 4 feet 4 inches diameter at inlet end, and 5 feet 6 inches at outlet, and was driven by a small 2 h.-p. engine. A large chamber to catch the coarse dust intervened between the roaster and the drying floor. Midway in each flue a movable sheet-iron partition, 1 foot high, was placed across the floor. The feed-pipe of the roaster was furnished with a sheet-iron shield, reaching and fitting closely to the bottom of the cylinder, for the purpose of protecting the fallen ore-stream from the draught. These devices proved very effective.

The crushed ore from the rockbreaker was dumped on to the drying floor, where it was spread, and the salt added to it. When dry the mixture was taken by trucks to a hopper, thence by an automatic feeder to the Wall rolls. These were used to crush to one-quarter inch size. The crushed ore fell into a revolving screen ; that passing through, forming 25 per cent. of the whole, was taken by a spiral conveyor to the fine-ore elevator ; the coarse portion fell into a link-belt elevator, and thence went to the smooth rolls. These rolls were set up tight. The crushed ore fell into a second revolving screen. All which passed through went to the spiral conveyor, thence by the fine-ore elevator (thin buckets bolted to a rubber belt) to the roaster bins. That which did not pass through the screen formed only a small percentage of the whole, and was returned to the link-belt elevator, and so to the smooth rolls again. At the end of the conveyor trough, where the fine ore fell into the elevator, a small pipe sampler was fixed, which furnished a continuous stream of pulp. From the sample so obtained the results given later on were calculated. The screens were covered by brass-wire cloth containing 480 holes to the square inch. The Westinghouse engine furnished the power for the whole of this portion of the plant, and gave satisfaction.

Owing to scarcity of ore, no effort was made to find the full capacity of the plant ; but 15 tons per shift of eight hours were crushed with ease. Apparently the capacity of the two sets of rolls was much greater. The first screen had a screening surface of about 25 square feet, the second about twice as much. With perfectly dry ore, and so long as the rolls were doing good work, these screens gave no trouble ; but it was evident that the second one would have been better if larger. The secret of successful crushing appears to be the perfect drying of the ore ; in fact, the ore crushes and screens better if it is quite hot. The salt was added at the drying floor, and was simply spread over the top of the ore in measured quantities, and became mixed in passing onwards through the mill. At first, owing to Customs regulations, rock salt was used, which had, of course, to be passed through the rockbreaker. Subsequently, ordinary coarse salt was used.

The mixed pulp was fed from the hoppers into the Howell roaster by a small spiral conveyor, driven from a pulley on the driving shaft of the roaster. The quantity was regulated by a sliding door on the hopper. The roaster was fired by wood at one end only. An auxiliary fireplace was tried, but proved unnecessary, and the waste heat from the roaster was also found sufficient for the drying floor. The roaster was tried at many different speeds, but we found one revolution in one and a half minute gave the best results, and that the capacity of the furnace did not exceed 15 tons in twenty-four hours.

The dust accumulating in the first large chamber was removed every night and added to the ore on the cooling floor. The dust from the drying floor flues was removed at greater intervals, and was leached in shallow charges by itself. If it were to be removed daily it could be sent to the vats mixed with the ordinary stuff on the cooling floors. The roasted ore was not allowed to remain long in the hot-ore hopper, but was quickly removed to the cooling floor, where it was left in a pile, about 3 feet high, until quite cool; this we found to take nearly a week. From the cooling floor the roasted ore was taken by a short tramway to Division III.

III. The Leaching Mill. This comprised:—

1. Three ore vats, 16 feet diameter, 7 feet deep.
2. Three precipitating vats, 10 feet diameter, 9 feet deep.
3. Two square tanks for wash-water precipitation.
4. Two square tanks for storing precipitates.
5. One square cement sump for solution.
6. One No. 5 gun-metal lined Blake pump.
7. Two stock solution vats.
8. Wrought-iron pressure tank.
9. Johnson's filter press.
10. Cast-iron tank for making sodium sulphide.
11. Two wrought-iron tanks for storing sodium sulphide.

Fresh water was supplied by gravitation from a dam above the mill. The steam boiler in the crushing mill furnished the steam required, but was too small for other requirements. Had the mill been run at its full capacity a separate boiler would have been necessary for the leaching mill.

The vats were made from a local timber, known as beech or white cedar, and were constructed exactly as recommended by Stetefeldt. They were provided with ejectors for circulating extra solution, and were well tarred with coal tar, as were also the launders and all ironwork. The stock solution vats were fitted with cast-iron pipes for heating the solution by steam. These large vats must not be left empty for many hours or they begin to leak, however well made they may be. The ore was charged into the vats dry, water being introduced from the bottom to saturate the charge while filling proceeded. The tailings were sluiced out when there was sufficient water to spare for the purpose. The extra solution was made up on the charge. The solutions were stirred by hand with a long wooden rabble during precipitation. The precipitates settled rapidly, and were run off daily. The lead was not precipitated separately. When sufficient precipitates had accumulated they were pressed in the filter press and dried. The pressure was produced by steam. A brick drying chamber heated by steam was built for drying the precipitates, but it was too slow; so the drying was done in a kind of oven,

heated by an open fireplace—a method which cannot be recommended. The dried precipitates were shipped to Swansea for sale.

The sulphide of sodium used for precipation was made exactly as recommended by Russell.

The mill, as a whole, worked well, very little handling being required. No difficulty was encountered in carrying out the process, and the workmen soon learned their duties. Since the mill was closed, the writer has visited the Marsac Mill, at Park City, and he was pleased to find that, in most respects, the Rivertree Mill compared favourably with that home of the Russell process, and, in some points, was decidedly its superior.

The mill was worked at intervals during 1893 by the mining company which built it. The extraction from the roasted ores was reported to have been good, but the losses during roasting were said to be very heavy. At the latter end of 1894 the mill came into the hands of the writer, who tried to work it as a customs mill, by buying ore from the miners on a fixed scale of charges. An effort was made to obtain accurate statistics of the work so done, and also to gain some further insight into the chemistry of the process. With this in view, Mr. E. S. Simpson, B.E., a graduate of the Sydney University Mining School, undertook a series of analyses of the ore treated and the various products.

Unfortunately, the failure of the ore supply compelled the closing of the mill, and curtailed Mr. Simpson's work, the results of which, however, so far as they go, will be given by that gentleman in the second part of this paper, which deals with the chemical side of the process. The present writer will confine himself to the practical and metallurgical results of the operations of the mill, as a customs mill, during the year 1895. The ore was bought upon assay, the sample being taken after the ore had passed through the rock-breaker, by the automatic sampling device before mentioned. For medium and low grade ores this method was found satisfactory; for high grade ores it gave results which were found untrustworthy. Automatic sampling of high grade ores has been abandoned at customs mills elsewhere, owing to similar experiences. The ore treated was of higher grade, and much less siliceous than the ore supplied for the experiments in 1891, and was not by any means an ideal ore for the process. Its composition is given in Mr. Simpson's paper. The high percentage of lead necessitated a very careful roasting, in order to prevent sticking, and doubtless added to the loss by volatilization, as the analyses show a great loss of lead in roasting. The sulphur in the ores existed in combination with the arsenic and zinc, and a portion of the lead and iron. The salt used was 12 per cent. of the weight of the ore.

Owing to the variety of the ores bought the chloridising varied daily, and the results were obtained only after the ore had lain

some time on the cooling-floor. The percentage chloridised ranged from 71 per cent. to 86·36 per cent. (See Table I.)

The loss in roasting amounted to 9·07 per cent., which represents the difference between the amount of silver in the ore mixture sent to the roaster, and that in the roasted ore and flue-dust sent to the vats; the loss in dust is included in this amount.

The leaching was carried on in the following way:—

The ore was leached with cold water for five hours, the wash-water during that period being run into the wash-water precipitating tanks. After five hours washing no silver was found in the wash-water which was then run to waste until the end of washing. The washed ore was then treated with eight charges of ordinary solution (hyposulphite of soda) of 1·5 per cent. strength, followed by a charge of standard extra, which stood in the charge, or was circulated for from four to six hours. This was followed by a charge of ordinary, and then by a second charge of extra of about one-half standard strength, then by two charges of ordinary solution, and finally by wash-water. The solutions were used at a temperature of from 40 to 60 degrees centigrade.

The above order of leaching was varied in one or two cases where delays occurred in the work, and more extra was used in an attempt to obtain a higher extraction.

Circulation of the extra solution was found more efficacious than allowing it to stand in the ore. When the extra solution stands in the ore more than a few hours its effect is destroyed.

The silver in the wash-water, which gave an acid reaction, was precipitated by sodium sulphide. The precipitation of the other metals in the wash-water was only partial. The wash-water precipitate settled rapidly, and the liquid was run off immediately it cleared. The precipitation of the hypo. solution presented no peculiarities. The sodium sulphide was measured by a bucket, and the end of precipitation was found by filtration and testing in the usual way. The rate of filtration through the ore was rapid—about 8 inches per hour. When the flue-dust was added daily to the roasted ore on the cooling-floor, in such a way as to become evenly distributed through it, no difference was found; but on one occasion (E in the Table) the flue-dust was not properly mixed, and in filling formed a cone-shaped layer in the vat, which prevented completion of the leaching, and necessitated the retreating of the contents. On removing the ore from the vat, the portion above the flue-dust layer assayed only 15 oz., while the lower portion assayed over 30 oz. per ton; the whole, after reroasting, averaging 35 oz.

It was generally found that the ore on top assayed much higher than the ore at the bottom of the vats. Vat F, for example, gave an average tailings sample assaying 3·9 oz. per ton, while ore taken from the upper portion assayed 3·1 oz.; from the middle,

4·2 oz.; and from the bottom, 12·4 oz. silver per ton respectively. In another instance the ore on top assayed 7·6 oz. per ton, while that near the bottom assayed 12·4 oz. The leaching of shallow charges (about 2 feet deep), consisting solely of flue-dust, went on slowly, but effectually.

In drying the precipitates the free sulphur generally caught fire and burned away; the assays represent the precipitates so treated.

They were sold in England on the following terms:—The copper (wet assay, less two units) was paid for at market C.B. rates; the gold at £4 4s. per ounce fine, and the silver at the full market rate for the fine silver contents, less 1d. per ounce fine, for refining. Owing to the intermittent nature of the work the precipitates were pressed irregularly, and varied widely in value. The annexed Table II. gives the assays of the various parcels, and explains itself. Owing to the great loss of solutions through leakage of the vats during the early stages of the work, before the nature of such large wooden tanks became understood by the workmen, no figures of the consumption of chemicals or of the actual extraction of silver can be given which would be at all reliable. Table I gives the result of each vat of ore treated. In the case of vats H and J, which represent work done under good condition all through, the clean-up gave an actual extraction in excess of the apparent extraction as calculated from the tailings assay of 0·5 per cent.

The ore in vats A, B, C, K, and L contained more sulphurets than the others, and show plainly their presence in the low extraction by ordinary solution in the mill compared with that in the assay office. Vats A, B, C represent 100 tons of tailings from some raw-leaching experiments upon sulphide ore, made by the mining company which built the mill. These tailings contained a large quantity of blende and arsenopyrite. Mr. Simpson's analyses represent only the new ore treated in vats D to M.

The result of the treatment of the ore alone was a mean extraction of 84·05 per cent. of the silver in the roasted ore and of 78·37 per cent. of the silver contained in the ore before chloridising.

Doubtless very much better results would have been obtained if the mill had been able to continue work long enough to enable us to profit by our experiences.

In conclusion, the following opinions have been arrived at by the writer as the result of his experiments and experiences since he first became interested in hyposulphite lixiviation, and from studying the experiences of others:—

(1) The Russell process is a good one under certain conditions and for certain ores, which latter are plainly indicated. It presents no difficulties of a serious nature, and its manipulations are easily learned by workmen.

(II) Moderately fine crushing is as necessary as it is for amalgamation.

(III) The roasting should be done in reverberatory furnaces; oxidation of the sulphur should be complete; and with heavy sulphuretted ores the salt should be added only after most of the sulphur has been driven off.

(IV) The ore should be leached in shallow charges, and the solution passed through continuously and rapidly. Time is a factor of importance all through the process.

(V) If possible (and the writer believes it is possible), the use of wood vats and tanks should be avoided. In this climate it seems almost impossible to keep such large wooden vessels tight, even for a few hours of emptiness.

Table I.

Vat.	Material treated.	Assay value of Roasted Ore per ton.	Extraction Tests in the Assay Office.		Mill Extraction, calculated from assay of Tailings, after—	
			Hypo.	Extra.	Hypo.	Extra.
		oz.	per cent.	per cent.	per cent.	per cent.
A	Tailings ...	18·75	72·3	73·9	26·5	65·0
B	Tailings ...	19·60	71·0	75·0	58·1	68·4
C	Tailings ...	20·90	74·4	80·7	32·1	47·5
D	Ore	71·85	86·36	87·96	85·95	89·53
E	Ore	68·25	84·25	86·38	....	51·19
F	E, reroasted	35·15	81·08	83·36	86·06	90·2
G	Flue Dust	62·35	....	81·15	82·2	84·29
H	Ore	73·00	80·35	88·43	86·58	85·39
J	Ore	71·50	74·69	90·42	80·84	86·00
K	Ore	85·90	84·25	87·84	53·26	89·00
L	Ore	68·25	84·47	86·89	43·08	85·06
M	Flue Dust	78·05	76·62	78·29	....	79·12

Table II.—Value of Precipitates.

Lot.	Copper (per cent.)	Silver (oz. per ton).	Gold (oz. per ton).	Remarks
1	12·5	2,432	2·25	Wash-water and weak solution.
2	12·3	8,550	5·25	Regular sulphides.
3	6·0	4,100	4·6	do.
4	12·7	907	0·8	Wash-water.
5	5·7	12,025	12·8	From ordinary solution only.
6	5·5	6,305	4·45	Regular.
7	7·85	12,219	15·0	Same as No. 5.
8	3·85	5,228	5·1	Regular.
9	8·1	2,631	2·22	Regular and wash-water precipitates mixed.
10	3·1	2,273	2·0	do. do.

PART II.—By EDWARD S. SIMPSON, B.E.

SINCE the publication of Stetefeldt's exhaustive treatise on hyposulphite leaching, very little can be said with reference to the chemical aspects of the Russell process that is not already contained therein. Since, however, more extensive experiments with this process have been made on the Rivertree ore than on any other in Australia, and since this ore differs considerably in composition from the American ores quoted by Stetefeldt, it may be useful to record the analyses of this ore, made during a short visit to Rivertree in 1895, and follow through the various reactions which took place during its chloridising and leaching.

In order to thoroughly understand these, it will be necessary first to explain the general principles upon which this process depends. These are, in brief:—

1. Native silver chloride and certain oxidised silver minerals are soluble in a solution of sodium hyposulphite.
2. Many unoxidised silver minerals, which are insoluble in the plain sodium salt, dissolve readily in a solution containing in addition cuprous hyposulphite.
3. By roasting unoxidised silver minerals with salt, they are converted for the most part into silver chloride.
4. Solutions of silver in hyposulphites are precipitated by sodium sulphides.

The fact that oxidised silver compounds are soluble in solutions of sodium hyposulphite, was known and applied practically by Von Patera as far back as 1858. His process has been found to give excellent results in the case of surface ores, in which all the silver is in the form of haloid salts, and on many ores which have been subjected to a thorough chloridising roast.

This solubility depends upon the fact that these compounds react with sodium hyposulphite, forming the corresponding salt of silver, which is insoluble in water, but dissolves readily when sufficient excess of the sodium salt is present to form a soluble double salt of the form $Ag_2 S_2 O_3, 3 Na_2 S_2 O_3$.

Metallic silver, which is of frequent occurrence in surface ores, dissolves somewhat easily in sodium hyposulphite, but only in the presence of free oxygen, in proportion necessary for the oxidation of the metal. When already existing as one of the haloid salts, no free oxygen is necessary to its solution, which is on that account more rapid. Silver arsenate and antimonate are also soluble, and although these compounds probably do not occur in nature, yet the question of their solubility becomes a vital one in practical working as will be explained later on. Silver sulphide and sulpharsenate and other minerals of a like nature are entirely

insoluble, and it is precisely at this point that the Von Patera process breaks down and the Russell process steps into the aid of the metallurgist.

Mr. E. H. Russell was the first to discover that silver sulphide and other compounds which are unaffected by sodium hyposulphite are soluble in a solution containing in addition cuprous hyposulphite, and that a solution of this nature, which he terms "extra solution," can readily be obtained by adding commercial bluestone (copper sulphate) to Von Patera's solution, which he terms "ordinary solution." It is the practical application of this discovery which forms the basis of the Russell process.

The chemistry of the process naturally falls into six divisions, viz. :—

1. The chloridising roast.
2. The preparation and stability of solutions.
3. The wash-water.
4. The ordinary solution.
5. The extra solution.
6. The precipitation and treatment of precipitates.

I. THE CHLORIDISING ROAST.

Although, as has already been stated, the chief difference between the Von Patera and Russell processes lies in the employment in the latter of a solution capable of leaching out unoxidised silver minerals from ores, and although in one or two instances this process has been known to give extractions in the laboratory up to 93 per cent. on raw ore, still, on the score of economy of both time and expense, it is generally found preferable to prelude the leaching of the ore with a more or less perfect roasting. Of all silver compounds, the chloride seems to be the most readily attacked by hyposulphite solutions, and therefore this roasting is almost invariably done with salt in order to convert the metals, and especially the silver, into chlorides at the expense of the chlorine in the salt rather than into oxides or sulphates.

As was only natural in a customs mill, the ore treated at Rivertree during the period under discussion was exceedingly complex in character, consisting of a mixture of both oxidised and sulphide ores from several distinct lodes. It has already been stated that these lodes at a depth consisted of a gangue of quartz in places largely replaced by talc, carrying argentiferous pyrites, galena, blende, and mispickel. Minute strings of proustite were frequently visible, and probably argentite. Near the surface these sulphides gave place to the natural products of their decomposition—cerussite, calamine, various oxides of iron, and kaolin, derived from the decomposed country rock. No metallic silver, or other silver

mineral, was visible in this gossan ; so that the precious metal was probably disseminated through it in the form of minute grains of silver chloride, bromide, &c.

The average composition of the raw ore treated in vats D to M was as follows :—

(*a*)

SiO_2	48·92	per cent.
Al_2O_3	11·77	„
CaO	2·81	„
MgO	·65	„
Pb	7·98	„
Cu	·31	„
Fe	13·16	„
Zn	·93	„
As	4·64	„
Sb	trace	
S	4·88	„

Percentage soluble in water, ·31.

The highly siliceous nature of this ore, combined with its low value in lead and copper, fully accounts for the failure of the blast-furnace which was erected at one time to treat the ore from the Wongabah lode.

In the preliminary roasting with salt, the first action which takes place is the volatilisation of half of the sulphur in the pyrites, the vapour burning in contact with the hot air to sulphur dioxide.

As the temperature rises, the various sulphides in the ore are oxidised more or less completely to sulphates, which in turn are gradually converted into oxides by volatilisation of the SO_3. The rapidity of this latter action varies greatly with the different metals ; the order in which the sulphates are decomposed being first, that of iron, then copper, silver, lead, and zinc. In the presence of salt, however, chlorine is liberated by the interaction of the salt and sulphur trioxide, and the chlorine reacts upon the sulphates and oxides of silver and the other metals with the formation of corresponding chlorides.

During the roast, much of the arsenic and antimony are volatilised, the rest remaining in the ore in the form of arsenates and antimonates. These salts of silver are found in the roasted ore as the result of the oxidation of proustite and pyrargyrite, and hence the importance of the question of their solubility in hyposulphite solutions.

The composition of the Rivertree ore after chloridising was :—

SiO_2	...	45·74
Al_2O_3	...	11·20
CaO	...	1·32
MgO	...	·68
Pb	...	3·43
Cu	...	·28
Fe	...	12·39
Zn	...	·86
As	...	2·14
S	Sol. in water ...	1·61
	Insol. in water ...	1·88

Percentage soluble in water, 12·17.

Lead compounds are always somewhat easily volatilised ; but, apparently, in the presence of salt, losses from this cause are considerably increased by the formation of the readily volatile chloride. Lead sulphate and oxide are soluble in hyposulphite solutions, at the expense of the latter's strength, and where it is not economical to recover the lead from the liquors by precipitation with sodium carbonate, this increased loss is a material advantage for this cause, and because of the resulting improvement in the grade of the precipitates.

Although a large excess of salt is used in the roasting, much of which exists undecomposed in the ore after it leaves the roasting furnace, a considerable amount of the silver may be left unchloridised, as may be shown by its insolubility in sodium hyposulphite. This is probably due to mechanical rather than chemical causes, the centre portions of the grains of silver sulphide being protected from oxidation by the film of chloride found on their surface and by enveloping fragments of quartz, etc.

In chloridising this ore at Rivertree in a Howell-White furnace, firm concretions were found to form on the sides of the furnace, and to increase so rapidly in the centre half of it as to reduce its internal sectional area by nearly one-half in a few weeks. Partial analysis of two samples of these concretions from different parts of the furnace, which are given below, show that they contained a large proportion of soluble salts, and were probably composed of partially roasted ore fritted together with sodium sulphate and a little chloride.

Analyses of Concretions.

		(*c*)	(*d*)
SiO_2	...	37·27	40·73
Al_2O_3	...	8·82	8·88
CaO...	...	1·15	1·19

	(c)	(d)
MgO	·34	·45
Pb	2·70	3·12
Cu	·09	·08
Fe	8·49	9·27
Zn	·91	·75
As	5·86	3·21
S { Sol. in water	4·96	3·88
S { Insol. in water...	2·16	2·82
Cl.	0·71	1·11
Ag. (oz. per ton)	59·00	58·00
Percentage of whole soluble in water	21·11	18·02

(*c*) is an average sample of the concretions from 12 to 18 feet from the discharge.

(*d*) is an average sample of the concretions from 6 to 12 feet from the discharge end of furnace.

With an ore of this description a considerable amount of fume is produced, a small part of which condenses on any projections at the end of the furnace, whilst the remainder is carried off into the flue-chambers, and collects there. The composition of a hard white scale on the feed-spout is shown in analysis (*e*); that of the flue-dust treated in vat M in analysis (*f*).

	(e)	(f)
SiO_2...	19·69	39·72
Al_2O_3	7·37	7·88
CaO...	1·20	1·29
MgO	·35	·75
Pb	20·29	11·40
Cu	trace	trace
Fe	7·82	14·91
Zn	1·50	·88
As	4·86	5·00
S { Sol. in water	2·34	1·20
S { Insol. in water	4·12	1·79
Ag. oz. per ton	55·00	62·00
Percentage of whole soluble in water	9·65	9·63

The feed-spout scale is largely composed of sulphate and oxide of lead, and oxide of arsenic with more or less partly-roasted ore carried over by the draught, which accounts for the 20 per cent. of silica contained in it.

The flue-dust forms an almost impalpable powder, made up of the finest portions of the ore carried out of the furnace by the draught with some volatile compounds of lead and arsenic.

II. PREPARATION AND STABILITY OF SOLUTIONS.

There are always at least three different solutions in use on a Russell process mill, viz., (*a*) ordinary solution, (*b*) extra solution, and (*c*) precipitating solution.

(*a*) Ordinary solution is prepared by dissolving crystallised sodium hyposulphite in water, the strength recommended for general use, which was adopted at Rivertree, being $1\frac{1}{2}$ per cent. in the crystallised salt, $Na_2S_2O_3 5H_2O$. This solution is very permanent under ordinary conditions, and even when heated to 50° C., at which temperature it is a much more energetic solvent for silver salts, it only oxidises extremely slowly to sulphate. It is unaffected by organic matter, and can, therefore, be stored in wooden vats. Its action on copper and copper alloys is much more rapid than on lead or iron; hence the lastnamed metal should be used for all pipes and taps, whilst india-rubber hose can be used for distributing. Owing to the permanency of this solution it can be employed over and over again, its strength being brought up to standard from time to time by the addition of the neccessary quantity of hypo. which can be determined by titration of the solution with standard iodine.

(*b*) Extra solution consists of a solution of sodium and cuprous hyposulphites formed by dissolving blue-stone in ordinary solution. The equation for its formation is:—

$$13\ Na_2S_2O_3 + 6\ CuSO_4 = 4\ Na_2S_2O_3\ 3\ Cu_2S_2O_3 + 6\ Na_2SO_4 + 3\ Na_2S_4O_6.$$

This requires the use of 2·15 parts of sodium hyposulphite to one part of bluestone. The standard extra solution in use at Rivertree was that recommended by Russell, and contained 1 per cent. of bluestone and $2\frac{1}{4}$ per cent. of crystallised sodium hyposulphite. If neutral or alkaline, this solution rapidly decomposes with precipitation of cupric hydrate; if, however, it be rendered slightly acid with sulphuric acid, this decomposition is considerably delayed even when the solution is heated to 50° C. It has been found best, however, not to attempt to keep this solution in stock, but make it as required, by running ordinary solution on to the vats through a sieve containing the requisite amount of bluestone.

(*c*) Precipitating solution:—Since silver chloride is readily soluble in hyposulphite solutions, evidently the precious metal cannot be precipitated in this form from the liquors, neither can it be precipitated by copper, owing to this metal dissolving in excess of sodium hyposulphite with the formation of extra solution which we have seen is an energetic solvent of metallic silver.

The well known affinity of copper for sulphur, and the complete insolubility of silver sulphide in ordinary solution render it possible to precipitate the silver in this form. The precipitant employed is sodium sulphide, which first throws down any copper remaining in the liquors, and then the silver; no extra solution remaining at this point to redissolve the silver sulphide formed.

The sodium sulphide is prepared by the action of sulphur on hot caustic soda. The latter is fed into an iron cylinder with sufficient water to cover it, and then heated to about 110° C. by blowing steam through it. Stick sulphur is then added in sufficient quantity to produce whichever of the many sulphides of soda with which it is deemed best to work. Russell recommended a mixture of the mono and bisulphides, to produce which 65 lb. of sulphur are needed for every 100 lb. of caustic soda.

On adding the sulphur to the hot caustic, a very violent reaction takes place, the heat produced being sufficient to cause the evolution of clouds of steam. Small quantities of sulphuretted hydrogen and sulphur dioxide are also formed, and can be recognised by their characteristic smell. These compounds are probably formed in accordance with the equation

$$2\ NaHO + 2\ H_2O + 6S = Na_2S + 3H_2S + 2\ SO_2.$$

The concentrated solution thus produced at Rivertree was diluted and stored in sheet-iron tanks. Owing to its somewhat rapid oxidation, it should not, however, be kept for many weeks at a time, but fresh solution made from time to time as required.

III. THE WASH-WATER.

The benefit of a preliminary washing with water is twofold— First, to rid the ore of any remaining sodium salts, which would tend to choke up the hypo solution, so that it could not be used over again; second, to increase the grade of the final sulphides by removing all soluble salts of iron, lead, &c., which would be precipitated by the sodium sulphide solution.

The salts of sodium remaining in the ore after chloridising are all very soluble in cold water, and are totally removed by the wash-water, together with sulphates and chlorides of Mn, Zn, Cu, Fe, Al, Ca, and Mg. After sinking through the first layer of ore the water becomes—from solution of these salts—a more or less concentrated brine, which is capable of dissolving still other compounds, such as silver chloride, which are practically insoluble in pure water. The liquor, therefore, as it comes from the vats always contains sufficient silver to render it necessary to preserve it, and precipitate it with sodium sulphide, as in the case of the hyposulphite solutions.

A sample of the wash-water liquor taken at Rivertree, after it had been flowing for two hours from the vats, gave a distinctly

acid reaction, and had a specific gravity of 1·060. It contained 8·59 per cent. of soluble salts of the following approximate composition :—

(*g*)

Na_2SO_4...	62·46
$NaCl$	26·58
$Al_2(SO_4)_3$	2·15
$CaSO_4$	2·45
$ZnSO_4$	2·43
$MgCl$	·49
Cu_2Cl_2	·34
Fe_2Cl_6	trace
Na_3AsO_4	·11

In speaking of the wash-water, we are brought face to face with one of the most interesting problems, from both a chemical and metallurgical point of view, connected with the Russell process. This is the so-called going-back of chlorination. This term is applied to the marked decrease in the percentage of the silver in the ore which is soluble in ordinary solution produced by the preliminary washing with water, and was originally ascribed by Mr. W. S. Morse, who was one of the first to investigate the matter, to the effect of undecomposed blende in the charge reacting on the silver chloride (which is soluble in ordinary solution) forming the insoluble sulphide.

Stetefeldt, in speaking of this matter,* says :—" ZnS in roasted ore is the principal, and in many cases the only cause of chlorinations going back." And, again :—†" The Aspen statistics seem to indicate that that portion of the going back of chlorinations, which is not corrected by the extra solution, is due to the effect of caustic lime, the effect of the latter being to precipitate gelatinous compounds round the particles of silver."

Mr. W. S. Morse in a recent paper, in reviewing this subject adheres to his original theory ; but Mr. L. D. Godshall, in criticising this paper, ascribes this going back to the presence in the ore of sulphurous acid, ferrous sulphate, or some other reducing agent, which converts the soluble silver chloride into metallic silver, almost insoluble in ordinary solutions under the ordinary conditions of working.

It seems to me that there is still another and a very important cause for this going-back, which, however, only operates when the wash-water is acid, as it was at Rivertree, and frequently is elsewhere. Once a vat has been used for leaching, the material of which it is built becomes more or less impregnated with hyposulphite salts. On adding the wash-water to a fresh charge of ore in such a vat, a small quantity of sodium hyposulphite goes into

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* Lixiviation of silver ores with hypo solutions, 1895, p. 65. †Ibid, p. 67.

solution, and attacks the silver chloride, converting part of it into insoluble silver hyposulphite, there being presumably not sufficient hypo in solution to form the soluble double, salt of silver and sodium. In the presence of a very minute amount of free acid, this silver hyposulphite is rapidly converted into silver sulphide, which we have seen is insoluble in ordinary solution. That such a series of reactions would take place under these conditions has been amply proved by the researches of Mr. C. H. Bothamly, F.I.C., F.C.S., into the chemistry of photographic printing. I only regret that neither time nor opportunity were at my disposal to prosecute this inquiry at Rivertree; but I hope that this paper may induce others, who are interested, to follow up this subject.

IV. THE ORDINARY SOLUTION.

This consists, as before stated, of a solution in water of sodium hyposulphite; the strength adopted being $1\frac{1}{2}$ per cent. in the crystallised salt, $Na_2S_2O_3 5H_2O$. It is capable of dissolving out most of the oxidised compounds of silver through the formation of the soluble double, hyposulphite of silver and sodium.

AgCl dissolves very readily in either cold or warm ordinary solution, a fact long taken advantage of in photography; but metallic silver and the arsenate and antimonate yield more readily to the attack of warm solution than cold; and, since this solution is very stable, it is advantageous always to heat it up to 45° or 50° centigrade before using.

Since both the bromide and iodide of silver occur somewhat frequently in silver ores in Australia, notably at Broken Hill, the author made some experiments on the solubility of the artificially-prepared compounds in a standard ordinary solution, with the result that silver bromide was found to dissolve almost as quickly as silver chloride, the co-efficient of solution being practically the same, viz., 0·3 of silver for one part of $Na_2S_2O_3,5H_2O$. Silver iodide dissolved more slowly than either the chloride or bromide, but finally gave a similar co-efficient, viz., 0·3Ag.

When the roasted ores contain sulphates of lead, or calcium, or quicklime, a considerable amount of hypo may be used up in dissolving these compounds with the formation of the corresponding double salt. Owing, however, to the highly siliceous character of the Rivertree ore, it is probable that very little of the hypo was consumed in this way.

V. THE EXTRA SOLUTION.

It is the rapid action of this solution on unoxidised silver minerals which gives to the Russell process its high value in the treatment of base silver ores. The greatest difference in effect between ordinary and extra solutions is seen in their action on metallic

silver and silver sulphide. Metallic silver is nearly nine times more soluble in the latter than in the former, whilst silver sulphide is absolutely unaffected by ordinary solution, but is rapidly attacked by extra solution. As a considerable amount of silver sulphide is frequently left undecomposed after the chloridising roast, the extra solution is generally found to extract 10 per cent. to 20 per cent. of the total silver in the ore after as much as possible has been removed by ordinary solution. Cu_2S is precipitated during the solution of Ag_2S ; but no precipitation of metallic copper can take place during the solution of metallic silver, owing to its ready solubility in sodium hypo-sulphite.

Before passing to the subject of precipitation, it may be as well to discuss at this point the best materials for vats. Three kinds of vats suggest themselves for use, viz., plain wood, wood lead-lined, and concrete. Mr. Hall, in the first part of this paper, has already drawn your attention to the unsuitability of the first-named in the hot dry climate prevailing in many parts of this continent, owing to its rapid shrinking when allowed to get dry. This has been found a considerable drawback to the use of wooden vats in Charters Towers and elsewhere in Australia.

In the chlorination works at Mount Morgan, the second kind has been used for many years with great success; but owing to the rapid action of extra solution on metallic lead, vats of this description cannot be looked upon as satisfactory for a Russell mill, even when the lead is protected by a coating of tar or pitch.

In South Africa, and more recently in Queensland, wood, as a material for leaching vats, is being superseded by concrete, which seems amply to satisfy all requirements. It was used with success at Rivertree for the stock solution sump, and when faced with neat cement, should make excellent leaching vats, which would not be appreciably affected by any of the solutions used in the Russell process.

VI. PRECIPITATION.

The sulphide of soda used to precipitate the silver is not a simple compound, but a mixture of various sulphides from Na_2S to Na_2S_5, the proportions in which the different sulphides occur being dependent on the relative quantities of soda and sulphur used in the preparation of the solution. Na_2S precipitates silver from hypo solutions regenerating sodium hyposulphite thus:

$$Ag_2S_2O_3 + Na_2S = Ag_2S + Na_2S_2O_3.$$

If any higher sulphide be used, a corresponding amount of free sulphur is precipitated with the silver thus:

$$Ag_2S_2O_3 + Na_2S + x = Ag_2S + Na_2S_2O_3 + x\ S.$$

Free sulphur is also precipitated by the action of sodium sulphide on any tetrathionate or ferric chloride in the liquor. In addition to Ag_2S and free sulphur, the precipitate will also contain sulphides of Cu, Pb, Au, Fe, and Zn, with some $Al_2(HO)_6$ and $CaCO_3$, which, after ignition of the precipitate, would be almost wholly converted into Al_2O_3 and CaS.

The Rivertree precipitates, after drying at a temperature which was sufficient to partially oxidise some of the sulphides, had the following composition :—

(*h.*)

Soluble salts	4·36	per cent.
Al_2O_3	2·41	,,
Ca	·85	,,
Ag	16·32	,,
Au	·016	,,
Pb	9·93	,,
Cu	3·66	,,
Fe	·98	,,
Zn	2·87	,,
S	55 84	,,
H_2O, O and CO_2	2·76	,,
	100·00	

In conclusion, it may be said that the Russell process offers a most interesting field for research to any chemist with the time at his disposal, the cause of the going-back of chlorinations especially needing elucidation.

No. 6.—ON THE OCCURRENCE OF PHOSPHATIC DEPOSITS IN THE JENOLAN CAVES, NEW SOUTH WALES.

By JOHN C. H. MINGAYE, F.C.S., Analyst to the New South Wales Department of Mines.

(*Read Saturday, January* 8, 1898.)

[*Abstract.*]

THE phosphate deposits were found by Guide Wyburd in Katie's Bower, Left and Right Imperial, Grotto Cave, and the Jubilee Cave—a branch of the Right Imperial Cave.

Geology.—Professor David, B.A., F.G.S., states, with regard to the geology of the caves district:—" The caves, which are large and very numerous, occur in a thick bed of limestone. The limestone is formed largely by corals, hydro-corallines (stromatorella being very abundant), and brachiopods; amongst the latter a large pentamerus predominates. The limestone is considered by R. Etheridge, jun., to be of Siluro-Devonian age. It is interstratified with a thick series of blackish, greenish, grey, and reddish brown clay shales, claystones, and cherts, these containing casts of radiolaria. The whole of the sedimentary series are intruded by quartz felsites and basic dykes rich in augite." Mr. Harpur, Assistant Curator to the Department of Mines, who recently visited the caves, informs me:—" A quantity of drift is associated with or immediately overlies the red and white marls which partly fill portions of the caves. The marls appear to graduate downwards, and are red and white in colour."

A sample of the reddish marl taken from the Devil's Coachhouse yielded on analysis as follows:—

Analysis.

Hygroscopic moisture	1·49
Combined water	3·01
Silica (SiO_2)	63·41
Alumina (Al_2O_3)...	18·02
Ferric oxide (Fe_2O_3)	7·33
Manganous oxide (MnO)	trace.
Lime (CaO)	·16
Magnesia (MgO)...	·79
Potash (K_2O	5·09
Soda (Na_2O)	trace.
Phosphoric acid (P_2O_5)	·08
Organic matter	·24
	99·62

(1 and 2.) Light, porous, friable substance, white in colour; soluble in dilute muriatic acid. Found in Katie's Bower, Left Imperial Cave.

This deposit occurs in veins in the marls. The presence of a large quantity of red clay is very noticable in this cave; in fact, it forms a boundary at one end of the earth deposit. The clay is also present in the "wash," being possibly the fine sediment deposited in the side channels and quiet pools of a one-time underground river.

There is no evidence of bat guano or bone breccia in any part of this cave.

Analysis.	I.	II.
Moisture and combined water ...	33·60	9·83
Silica (SiO_2)	·70	50·10
Alumina (Al_2O_3)	26·83	13·88
Ferric oxide (Fe_2O_3)	·72	8·65
Lime (CaO)	8·10	1·02
Magnesia (MgO)	·14	·14
Potash (K_2O)	·09	1·35
Soda (Na_2O)	absent	trace.
Phosphoric acid (P_2O_5)	30·04	15·38
Carbonic acid (CO_2)	·15	·12
Chlorine (Cl)	minute trace	......
	100·37	100·47

No fluorine or sulphur trioxide present.

(3.) The deposit was found on the floor of the Grotto Cave, and is protected with a hard surface, covered with small gnarled excrescences, found to be gypsum. Mr. Harpur, who examined this deposit, informs me "that it would appear as if it resulted from the alteration of the limestone from below, and is not connected in any way with the drift or marls."

There are similar deposits of this material in the Bone Cave, Lucas Cave, and in the Wool-shed Imperial. No indications of bat guano or bone breccia were observed.

Two samples of this material, very similar in appearance yielded on analyses as follows:—

Analysis.	I.	II.
Moisture and combined water ...	16·82	22·59
Silica (SiO_2)	37·82	2·78
Lime (CaO)	22·66	31·52
Magnesia (MgO)	·32	·09
Alumina (Al_2O_3)	·64	·10
Ferric oxide (Fe_2O_3)	minute trace	absent.
Potash (K_2O)	·11	trace.
Sulphur trioxide (SO_3)	5·39	28·67
Carbonic acid (CO_2)	·24	·10
Phosphoric acid (P_2O_5)	15·71	14·50
	99·71	100·35

No fluorine detected. A minute trace of chlorine present.

(4.) Light fluffy fungoid substance found in the Fairy's Grotto, Wilkinson's Cave, Left Imperial.

Two samples of this substance were received. The first, which weighed $1\frac{1}{2}$ grammes, Guide Wyburd states, "was compressed into a small match-box, and would fill your hat in its natural state. It is so light that, when you blow at it, it falls off the roof and sides like snow." It is stated to only occur in one cave—that is, at the end of the Wilkinson Cave.

Analysis.	I.	II.
Moisture and combined water ...	1·88	1·48
Calcium carbonate ($CaCO_3$) ...	76·03	72·57
Magnesium carbonate ($MgCO_3$)...	6·12	5·28
Strontium carbonate ($SrCO_3$) ...	trace	trace.
Alumina and ferric oxide (Al_2O_3 and Fe_2O_3)	1·46	1·94
Silica (Si_1O_2)	13·22	17·26
Phosphoric acid (P_2O_5)	·28	minute trace.
Organic matter	1·32	1·14
	100·31	99·67

The fungoid growth appears to be very rapid, for since the sample was received it formed in large quantities, and has the appearance of very fine wadding.

(5.) White pulverulent substance found in the Left and Right Imperial Caves.

Analysis.	I.	II.
Moisture at 200° C.	9·67	9·50
Loss from 200° C. to red heat ...	18·23	18·19
Alumina (Al_2O_3)	20·48	20·70
Ferric oxide (Fe_2O_3)	·18	·20
Lime (CaO)	trace	trace
Magnesia (MgO)	do	do
Potash (K_2O)	8·89	9·01
Insoluble matter (sand, &c.) ...	1·07	1·12
Phosphoric acid (P_2O_5)	40·86	40·83
	99·38	99·55

A trace of ammonia detected. No fluorine, chlorine, or sulphur trioxide present. The analysis shows this deposit to be identical with the mineral minervite—a hydrous phosphate of alumina and potash, previously described by Adolphe Carnot (Jour. Chem. Soc., vols. lxix and lxx, page 529).

(6.) Nodular, greyish-coloured substance, found in the Imperial Cave.

Analysis.

Moisture at 100° C.	6·79
Combined water	3·52
Silica (SiO_2)...	54·13
Alumina (Al_2O_3)	15·13
Ferric oxide Fe_2O_3)...	7·46
Lime (CaO)...	absent.
Magnesia (MgO)	minute trace.
Potash (K_2O)	1·69
Soda (Na_2O)...	·87
Phosphoric acid (P_2O_5)	10·63
	100·22

(7.) White saline substance, exuding from crevices in the Devil's Coach-house. A qualitative analysis proved this salt to be nitre (potassic nitrate). A small quantity of lime, magnesia, chlorine, and sulphuric acid was detected. The author suggests that the phosphatic deposits were due, in the first case, to sedimentary silt, containing bones derived from the remains of animals, brought to their present location by an ancient river. The presence of large quantities of drift, fine river wash, red and white marls, in and above the caves, all tend to point in this direction.

The present deposits are of a secondary formation, due to the action of acidulated waters containing carbonic, organic acids, &c., which have percolated through the primary deposits of drift, silt, &c., thereby dissolving the bone material, and acting on the marls dissolved a portion of the alumina and potash, the solution containing the phosphates having been re-deposited under conditions favourable for their separation.

The origin of the deposits, however, and the conditions under which they have been redeposited is exceedingly interesting, and is open to wide discussion.

With regard to the extent of the deposits, it is impossible at present to form any opinion, owing to the difficulty of access to the Caves. It is probable, however, that the supply is very limited.

My thanks are due to Mr. Harpur, Assistant Curator to the Geological Survey Branch, for the second collection of phosphatic deposits exhibited at this meeting, also for notes made during his recent visit to the Caves.

The analysis of No. 2 was kindly made for me by Mr. H. P. White, Assistant Analyst in the Laboratory.

No. 7.—NOTES AND ANALYSES OF SOME NEW SOUTH WALES PHOSPHATIC MINERALS AND PHOSPHATIC DEPOSITS.

By JOHN C. H. MINGAYE, F.C.S., Analyst to the New South Wales Department of Mines.

(*Read Saturday, January* 8, 1898.)

(1.) Pyromorphite from Braidwood, near Little River :—

Chemical Composition.

Lead oxide (PbO)	69·40
Metallic lead (Pb)	6·57
Phosphoric acid (P_2O_5)	15·22
Vanadic acid (V_2O_5)	trace
Chlorine (Cl)	2·26
Ferric oxide (Fe_2O_3)	·62
Lime (CaO)...	trace
Insoluble in acids (Gangue) ...	4·67
Moisture	·86
	99·60

No gold or silver detected.

(2.) Apatite Crystals from Gordonbrook :

Chemical Composition.	I.	II.
Lime (CaO)	48·73	48·63
Calcium (Ca)	3·81	3·82
Phosphoric acid (P_2O_5)	41·22	41·11
Chlorine (Cl)	1·28	1·32
Fluorine (Fl)	2·86	2·92
Magnesia (MgO)	·19	·21
Ferric oxide (Fe_2O_3)	·76	·72
*Gangue	1·32	1·25
Water	·29	·29
	100·46	100·27

† Mr. Geo. W. Card, A.R.S.M., F.G.S., has described the mineral as occurring in pinkish-white crystals, associated with an actinolitic substance, in narrow veins traversing granite.

* The gangue was found to consist of silica, alumina, ferric oxide, lime, magnesia, and a minute trace of phosphoric acid.

† Records of the Geological Survey of New South Wales, vol. v, Part II, 1897.

(3.) Marsupial excrement.—This substance had the appearance of solid bitumen, and has on several occasions been sent for examination. I am informed that it is usually found in small solid masses in caves, or crevices between rocks. A partial analysis yielded as follows:—

Total nitrogen...	2·24 per cent.
Equal to potassic nitrate	16·15 ,,
Phosphoric acid	·377 ,,
Insoluble matter (sand, &c.)	30·570 ,,

The whole of the nitrogen appears to be combined with potash, and the major portion of the phosphoric acid is in a soluble form.

(4.) Phosphatic deposit from Moruya Caves.—A partial analysis yielded as follows:—

Phosphoric acid (P_2O_5)	27·80 per cent.
Equal to tricalcic phosphate ($Ca_3P_2O_8$)	60·70 ,,
Calcium carbonate ($CaCo_3$)	3·29 ,,
Insoluble matter (sand, &c.)	11·68 ,,
Nitrogen, equal to ammonia	2·977 ,,

(5.) Phosphatic deposit from Moruya Caves.—A partial analysis yielded:—

Phosphoric acid (P_2O_5)	29·83 per cent.
Equal to tricalcic phosphate ($Ca_3P_2O_8$)	65·11 ,,
Calcium carbonate ($CaCo_3$)	8·18 ,,
Insoluble matter (sand, &c.)	·82 ,,
Nitrogen, equal to ammonia	·453 ,,

(6.) Fine gem sand from the Tooloom Alluvial Gold-fields:—

Cerium oxide	6·20 per cent.
Thorium oxide	0·45 ,,
Lanthanum oxide ... ... } Didymium oxide ... ... }	4·30 ,,
Phosphoric acid	3·07 ,,

(7.) Coarse gem-sand from the Tooloom Alluvial Gold-fields:—

Cerium earths as oxides	1·96 per cent.
Phosphoric acid	1·10 ,,

Both these samples consist largely of small zircons. A small quantity of chrome iron-ore is also present, and a few dwt. of gold per ton.

No. 8.—ON MODERN METHODS OF TEACHING CHEMISTRY.

By W. J. Clunies Ross, B.Sc.

(*Read Monday, January* 10, 1898.)

No. 9.—ON "RED RAIN" DUST.

By Thos. Steel, F.L.S., F.C.S.

(*Read Monday, January* 10, 1898.)

From time to time records of the fall of dust, either alone or accompanied by rain, are received from various parts of the colonies, in common with the rest of the world.

Although it is extremely probable that in the great bulk of these cases the dust is merely of terrestrial origin, it is interesting when positive facts regarding the source of the material can be ascertained. On December 27th, 1896, there occurred over Melbourne and a considerable area of Victoria an unusually heavy fall of dust of a red colour which was carried down by accompanying rain.

Various observers have made known the results of microscopical examination of dust from this shower; but, so far as I am aware, no chemical analysis of it has been published.

By means of a large paper-filter, my friend, Mr. W. E. Appleby, who was then resident at Moonee Ponds, near Melbourne, collected a very clean sample of the dust, which he kindly handed to me for examination. The sample was sufficient to enable me to determine the amounts of the leading constituents with a fair degree of accuracy. The following are the figures of analysis :—

	Dried at 110° C.
Organic matter,* &c. (loss on ignition) ...	10·70
Sand, insoluble and undetermined	66·23
Soluble silica	·75
Ferric oxide	4·68
Ferrous oxide	·50
Alumina	15·16
Lime	1·36
Sulphuric anhydride	·62
	100·00

The above may be considered as a characteristic example of ordinary surface soil such as is derived from the weathering of volcanic rocks. In appearance and composition it agrees closely with volcanic soils from such widely separated localities as Northern Queensland, New South Wales, and Fiji, which I have examined.

* Containing nitrogen .. .. ·30
Moisture in air-dried sample .. .. 6·08

Besides the diatoms noted by Messrs. Brittlebank, Stickland, and Shephard,* my own microscopical examination disclosed the presence of a few lepidopterous scales. Mr. L. Hart† states that he was able to microscopically identify crystals of amethyst and garnet. I have not, however, sufficient experience in this direction to enable me to confirm the identification.

There appears to be no feature connected with the fall, or in the nature and composition of the dust, to lead us to infer that it originated outside of Australia.

No. 10.—ON THE WATER OF THE WATER-VINE.

By W. M. Doherty, F.C.S.

(*Read Monday, January* 10, 1898.)

[*Abstract.*]

One of the sources from which the thirsty traveller in parts of tropical and sub-tropical Australia may allay his thirst is the water vine (*Vitis hypoglauca ?*). This vine is often found of considerable dimensions, though it is more frequently met with from 1 to 3 inches in diameter, hanging from and interlacing the surrounding forest like ropes or cables. The method for obtaining water is either to cut off several lengths of the vine and allow it to drain into a billy, or, if a large quantity of water is required, to select a fairly large specimen and cut it right through near the ground, then, by climbing as far up as possible, to partially sever it. A copious flow of water is the result. During a trip in the Tweed River district I have several times quenched my thirst by this means with a thoroughly enjoyable, clear, sparkling, palatable water, possessing a faintly, acidulous taste. Since partaking of this water I endeavoured to discover something about its composition, but could find no reference whatever. I, therefore, sent for samples of the water. The quantity sent me, though carefully collected, was insufficient for anything like a full investigation. The water is the sap which the vine has extracted from the soil in the demand for nourishment. I have found it to contain 39 grains of solid matter per gallon, 28 grains of which consisted chiefly of tannin, and some allied substance, which caused the water to darken on exposure to the air, together with certain proteid substances which could not be identified. The remaining 11 grains of solid matter consisted of potassium, calcium, magnesium, sodium, sulphuric acid, chlorine, phosphoric acid, carbonic acid, &c.

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* "Victorian Naturalist," xiii, 125.
† "Australasian Photographic Review," 1897, 9.

No. 11.—ON THE ESTIMATION OF WHEATMEAL IN OATMEAL BY A GRAVIMETRIC PROCESS.

By W. M. Doherty, F.C.S.

(Read Monday, January 10, 1898.*)*

Oatmeal is frequently found largely adulterated with wheatmeal. The well-marked and characteristic differences existing between the starch granules of the oat and the wheat render the discovery of this fact a matter of more or less simplicity. At the present time, the method used for estimating this adulteration is wholly microscopical. But it may have occurred to some of those who have to deal with this question that the counting of starch granules as a means of arriving at percentages of mixed "meals" is not altogether satisfactory, or devoid of objection; for, in the first place, it is a very difficult matter to obtain a slide that will fairly represent a large sample. The quantity of the sample under observation in the microscopic field of vision is always so minute that the preparation of a large number of slides becomes necessary in order to obtain even an approximate degree of accuracy. This, at least has been my experience, notwithstanding a most careful mixing of the samples undergoing analyses. In the second place, a correct estimation of the proportion of different starch granules does not imply the same correctness with regard to the meals in which the granules are found. This will be evident from the fact that the percentage of starch in wheat is greater than the percentage of starch in the oat, the ratio being often as 65 to 50.

The means which I now propose for the substitution of the quantitative microscopical method, has the advantage of bringing the balance into requisition, and depends upon the difference in the quantities of fat naturally present in the oat and in the wheat.

It will be obvious that before any data of value can be obtained from a given sample, it will be essential to discover if there is constancy in the fat-yields of both the wheat and the oat. In the numerous works treating or touching on the composition of these cereals, the fat content of neither the one or the other is quite constantly stated, but varies within certain narrow limits.* Acknowledging this variation, I do not think, though it be found to exist universally, that it will at all affect the general application or utility of this process. However this may be, my own determinations of the fat in genuine oatmeal and in wheatmeal procured in Sydney, and extending over several months, show in the case of

* European and American observers place the fat yield generally between 6 and 7 per cent.

the oatmeal an almost absolute constancy which I did not hope to find, and which in itself seems well worthy of remark. Thus out of twenty samples of oatmeal—twelve procured ready ground, eight made from oats procured as the occasion offered—nineteen showed the following strikingly concordant results :—

Percentage of Fat in Oatmeal.

No.	℔ cent.	No.	℔ cent.
1	7·20	11	7·30
2	7·35	12	7·20
3	7·30	13	7·15
4	7·21	14	7·34
5	6·42	15	7·21
6	7·20	16	7·36
7	7·30	17	7·41
8	7·32	18	7·21
9	7·30	19	7·30
10	7·30	20	7·25

No. 5 is the only one of the series that shows any marked divergence. The explanation of this is, that this sample, though genuine, had been subjected to treatment by the makers, which most probably modified the composition and occasioned a loss of fat. Omitting No. 5, the mean percentage of fat in nineteen samples amounted to 7·27.

The following table shows the percentage of fat found in each of twelve parcels of wheatmeal (*i.e.*, the wheat less the bran) made from samples of wheat, some kindly supplied by Mr. Guthrie of the Agricultural Department, others procured promiscuously from grain shops from time to time :—

Fat in Wheatmeal.

No.	Per cent.
1	0·94
2	0·98
3	1·00
4	1·20
5	1·11
6	0·76
7	0·96
8	0·99
9	1·16
10	1·21
11	1·03
12	0·96

Mean of the 12 = 1·02.

We have now as our constants 7·27 for the oatmeal and 1·02 for the wheatmeal.

In the light of the determinations herein mentioned, these figures, I think, are justified, subject, of course, to any modification that future and more extended investigation may render necessary.

Having established the presence of the adulterant, by microscopical recognition of the starch granules, it remains to make an estimation of the fat a given sample contains, in order to arrive at the degree of adulteration. The following is the formula for the calculation :—

$$\text{Percentage of wheatmeal} = 100 - \left(\frac{\text{Oat constant} - \text{percentage of fat in sample.}}{\text{Oat constant} - \text{wheat constant.}}\right)$$

I have found this process give good results when applied to mixtures containing known quantities of each meal. For example : A mixture of equal parts of oat and wheatmeal gave 4·2 per cent. of fat then

$$100\left(\frac{7{\cdot}27 - 4{\cdot}20}{6{\cdot}25}\right) = 49{\cdot}1 \text{ per cent. of wheatmeal.}$$

Another sample prepared by mixing together 70 parts of oatmeal and 30 parts of wheatmeal yielded 5·32 per cent. of fat, equalling 31 per cent. of wheatmeal. Both these results tend to confirm the process, being very close to the actual truth.

I have not considered the question of the sophistication of oatmeal with grain other than wheat, because this latter is the only adulterant generally used in Sydney.* However, it is fortunate that the fat content of any grain that might lend itself to the purpose, is low.†

In this investigation the fat was extracted in each case from 5 grammes of the meal by petroleum ether, acting in the Soxhlet apparatus, with ample condenser, for from two to three hours. Schleicher and Schull's patent thimbles were used to contain the meal, which was dried in the air-bath immediately before extraction. The petroleum ether was also water free. The fat was caught in a small wide-mouthed flask, and after the disposal of the ether, was dried at 100° C. in the air-bath, until constant in weight.

* In England the chief adulterant of oatmeal is said to be barley meal.

† Barley, for instance, according to Blyth, contains 1·7 per cent. of fat.

No. 12.—MANGANESE NODULES FOUND AT ONYBYGAMBAH.

By W. M. Doherty, F.C.S.

(Read Monday, January 10, 1898.)

During a journey through dense scrubland in the neighbourhood of Onybygambah, on the Tweed River, my attention was frequently attracted by numerous dark-coloured nodules, or pellets, scattered about in some places in all directions. Some of these pellets were dark and glossy, and looked like seeds, others were of a dull-black colour, with no specially-marked characteristics. My first impression was that some of them were seeds, until closer observation proved them to be of earthy origin. They varied in size from about that of a pea to about that of a Barcelona nut. A small proportion were almost perfectly spherical, the majority, while tending towards the spherical, being irregular in shape. They were all soft enough to be easily divided with the teeth. Separate analysis of three of them showed the following composition :—

	Per cent. (1)	Per cent. (2)	Per cent. (3)
Gangue	49·60	50·20	32·10
Fe_2O_3 and Al_2O_3 ...	11·20	8·70	14·00
MnO_2...	24·70	25·00	40·60
$Mg\ CO_3$	2·00	2·60	3·10
Organic matter ...	12·00	12·80	10·00

The occurrence of manganese, in the form now described, spread over a wide area is new to my experience, and is here merely recorded.

No. 13.—NOTES ON THE CONSTITUTION OF GLUTEN.

By F. B. Guthrie, F.C.S.

Read Monday, January 10, 1898.

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No. 14.—NOTES ON SOME SIMPLE LABORATORY CONTRIVANCES.

By A. N. Pearson.

(Read Monday, January 10, 1898.)

SECTION C.

GEOLOGY AND MINERALOGY.

PRESIDENTIAL ADDRESS.

By Captain F. W. HUTTON, F.R.S., F.G.S., &c., Curator, Canterbury Museum, Christchurch, New Zealand.

(*Delivered Saturday, January* 8, 1898.)

EARLY LIFE ON THE EARTH.

ONE peculiarity of geologists is that we receive new facts with suspicion, but welcome theories with open arms, provided they are properly introduced by authority. This has always been so from the beginning. It was a hundred and fifty years before geologists would believe the simple fact that a fossil shell *was* a fossil shell; and it was more than a hundred and fifty years before they would abandon the official theory that fossil shells had been buried during the Noachian deluge. It is the same at the present day; facts of observation are long disbelieved, while exploded theories die hard.

I do not say this in our disparagement, for there are good reasons why it should be so. Facts, especially palæontological facts, are usually discovered by members of the rank and file, and generally they are incomplete facts which have to be filled out with inferences, often erroneous, but which are supposed to be parts of the facts. Thus suspicion is begotten, and we often rightly refuse to receive incomplete facts until they have been verified by other discoveries, which may not take place for a long time. Theories, on the other hand, are usually started by someone in authority, whose position guarantees him a respectful hearing, and whose great knowledge is sure to make the theory appear plausible at the time. The ordinary geologist submits at once with the comfortable feeling of a patient who has placed himself in the hands of his doctor.

I make these few prefatory remarks because in this address I shall mention a number of facts of observation, some of which

have, I think, been received with an undue amount of suspicion; and I shall illustrate and, I hope, enliven them with one or two speculations of my own, which I trust you will receive kindly. To proceed now to my theme.

Palæontologists began with the younger fossils, and worked downwards. From the time of Cuvier and Brongniart in France, and William Smith in England, the palæontology of the Cainozoic, Mesozoic, and newer Palæozoic rocks made rapid progress; and in 1833 Murchison and Sedgwick commenced to unravel the older Palæozoic of Wales. The fossils were described by our esteemed friend, Sir Frederick McCoy, and others in Britain, in Europe, and in North America, until a fairly rich fauna was known down to the base of the Cambrian. Here fossils suddenly stopped, but so rich in species was the Cambrian fauna that it was predicted that, sooner or later, fossils would be found in pre-Cambrian rocks; and this prediction—which was based on the theory of organic evolution—has been verified within the last few years.

The first attempt at verification ended in disappointment. In 1865 Sir W. Logan and Sir J. W. Dawson announced that a gigantic foraminifer, which they called Eozoön, had been discovered a few years previously in the Laurentian rocks of Canada; but the announcement, at first received with favour, has, as I shall presently explain, fallen into discredit. Other discoveries, however, have proved more satisfactory. So far back as 1864 Mr. Billings found fossils in Newfoundland, which both he and Sir W. Logan thought at the time to be Cambrian, but which have since (in 1888) been shown to be pre-Cambrian. In 1883, and again in 1890, Professor Walcott announced the discovery of undoubted organic remains in the pre-Cambrian of Arizona. In 1889 Dr. G. F. Mathew read a paper to the Royal Society of Canada on some lower Cambrian fossils from New Brunswick, which are now, like those from Newfoundland, considered to be pre-Cambrian. Also, in 1892, Dr. C. Barrois discovered radiolarians and sponge-spicules in the pre-Cambrian rocks of Brittany, descriptions of which were published in 1895 by Dr. Cayeux.

Here, at last, we seem to have reached a palæontological base; for although radiolarians and sponges are not the lowest of animals, they are the lowest which contain any hard parts capable of being preserved, and are, therefore, the lowest in organisation of any animals we can hope to find fossil. Their position too, as I shall point out directly, is, probably, in the oldest system of rocks in which we can ever hope to recognise fossils; and they are, no doubt, as old or older than any other known organisms. Consequently, the palæontological sounding-line appears to have touched the bottom. A glance at what we know, or what we may legitimately surmise, about the early history of the earth will help to give us clearer notions on this dictum of a palæontological base.

We know as a fact that the earth is a hot body travelling through space which is intensely cold. It must, therefore, be cooling. Consequently, in the early days of its history, it must have been very much hotter than it is now. There are, indeed, reasons for thinking that at a very remote period the earth was actually molten owing to the intense heat, when, of course, the whole of the water of the ocean must have been in a state of vapour, and formed part of the atmosphere. As the temperature lowered, this aqueous vapour would condense and fall on the surface of the earth as hot rain. The first ocean would, therefore, be almost at its boiling-point, and would gradually cool down; but no life could exist in the ocean or on the land while the temperature much exceeded 200° F., which, so far as we know, is the highest temperature in which plants can live. This period of the hot ocean was, therefore, the Azoic era of the earth's history which, as the cooling progressed, passed into the Protozoic and then into the Palæozoic era, which includes the Cambrian period. At first the ocean must have been nearly uniform in temperature from the equator to the poles; but climatic zones appear to have been established in the Silurian period, if not earlier.

The pre-Cambrian rocks have received various names in different parts of the world; but, as they are better developed and more easy to decipher in North America than elsewhere, it is probable that so soon as the officers conducting the geological surveys of Canada and the United States agree on a classification and a nomenclature, it will be universally adopted. At present this is not the case, and, in this address, I have followed for the most part the Canadian authorities who first discovered these rocks, and who have for many years devoted an immense amount of labour to mapping them.

The oldest rock system known to us is composed chiefly of gneiss, sometimes passing into granite, and it probably represents the Azoic era. It is called the Laurentian system. Above it, in discordant sequence, is found in Canada a series of schists, arkoses, quartzites, greywackes, and schistose conglomerates called the Huronian system, which probably represents the Protozoic era. However, in order to avoid using theoretical names, which may be incorrect, the Laurentian and Huronian are called collectively the Archæan era.

Immediately above the Huronian there is a great unconformity, marking a considerable interval of time, and the succeeding rocks are called Keweenewan in Canada and Algonkian in the United States. They are composed of a great thickness of sandstones and slates—sometimes locally altered into schists—which underlie the Cambrian system, the base of which is marked by what is known as the *Olenellus fauna*, from the occurrence in it of the trilobite called *Olenellus*. Let us look at these more in detail.

THE LAURENTIAN PERIOD.

The Laurentian in Canada consists of two formations. The lower—known as the fundamental gneiss—is of igneous origin, and probably represents the more or less altered remains of the original crust of the earth. The upper formation consists of limestones and clastic rocks, evidenty of aqueous origin, which are called the Grenville and Hastings series. The argillaceous beds interstratified with the limestones have been changed into a rock, which is also called gneiss, although different in chemical composition from the fundamental gneiss. The Grenville series is supposed by Messrs. Adams and Barlow, of the Geological Survey of Canada,* to have been deposited at a time when the fundamental gneiss, which formed the bed of the ocean, was in a semi-molten or plastic condition, and the sediments sank down into the gneiss, so that in places they were entirely enwrapped by it. It is in this Grenville series that the structure called *Eozöon canadense* has been found.

It was the macroscopic characters of *Eozoön*—the regular concentric layers of which it is generally composed—which first gave rise to the idea that it was of organic origin. But these regular layers are sometimes very few in number, the greater part of the supposed organism being quite irregular in structure; indeed some specimens are without any arrangement at all and have been called *Archæosphærina*, under the idea that they belonged to a different genus to *Eozoön*. In its microscopic appearence *Eozoön* must closely resemble some of the Foraminifera or it could not have deceived such experienced observers as Dr. Carpenter and Professor Rupert Jones. However, Mr. H. J. Carter and Professor Möbius never allowed that *Eozoön* was organic, and Professor Zittel, although at first favouring the view that it was a Foraminifer, afterwards changed his opinion. Other specimens from Bavaria, Bohemia, Ireland, Scandinavia, and Brazil, which at first were supposed to be *Eozoön*, are now acknowledged to be inorganic, and somewhat similar structures, have been found in a calcareous vein-stone in eastern Massachusetts and in an altered limestone from Vesuvius.

It is, however, chiefly the position in which *Eozoön* is found which makes it impossible to believe that it is of organic origin. Professor Bonney, has pointed out that the original *Eozoön* occurs on the periphery of blocks of a variety of pyroxene called Malacolite, surrounded by crystalline limestone, and that it is formed by grains of this Malacolite, generally altered into serpentine, scattered through the limestone.† On the organic hypothesis these blocks

* American Journal of Science and Art, March, 1897.
† Geological Magazine, 1895, p. 292.

of pyroxene were the rocks in the ocean on which *Eozoön* grew; but evidently this cannot be the case for the blocks are segregation masses and were, no doubt, formed at the same time as the grains of serpentine which are supposed to infiltrate the organism.

Also, the supposed canals are sometimes filled with dolomite which is usually altered calcite, and is rarely deposited in cavities of unaltered calcite.

The great thickness and extent of the limestones with which *Eozoön* is associated forbid the idea that they are entirely the result of hydrothermal action on lime-bearing silicates; but it does not necessarily follow that they must be organic. Also, we can hardly suppose the large quantities of graphite found in these limestones to be organically derived, for if this was the case it must have come from marine plants—no others being in existence—and as we have no knowledge of any mineral carbon-compounds having thus originated in large quantity in any other period, we should have to suppose that seaweeds were either more abundant or more capable of being preserved in the Archæan era than at any later time. The occurrence of graphite and limestone together suggests a common origin for both, and as we know that metallic carbides occur, not only in meteorites, but also in the terrestial iron of Ovifak in Greenland, it seems probable that both graphite and limestone may be due to the decomposition of calcium carbides by hot water. At any rate, if the officers of the Canadian survey are right in their ideas as to the genesis of the Grenville series, we cannot possibly suppose that the limestones are of organic origin, for no organism could have existed under such conditions.*

HURONIAN LIFE.

No undoubted traces of life have been found in the Huronian of America; but it is probable that the Radiolarians and sponges discovered by Dr. C. Barrois, in Brittany, should be placed in it. A short account of the geological position of these fossils will be necessary to explain this.

In Southern Brittany, from Finisterre to Vendée, a remarkable graphite-bearing quartzite is found interbedded in a series of gneisses and mica-schists, which cover unconformably the Laurentian fundamental gneisses of the district. Further north, in the Department of the Côtes du Nord, the graphitic quartzite reappears; but here it is interbedded with phyllites and schists forming the series of Saint-Lô, which is undoubtedly pre-Cambrian. It is in this graphitic quartzite, in the neighbourhood of Lamballe, that the fossils were found. In Southern Brittany the graphitic quartzite appears to be near the top of the system as these developed;

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*I have not seen Dr. Mathews' paper on Archæozoön and Sponges from the Upper Laurentian, near St. John, New Brunswick, in the Bulletin of the Nat. Hist. Society of New Brunswick; but their organic nature has been disputed by Dr. H. Rauff, of Bonn.

but in Northern Brittany it occurs near the base of the series of Saint-Lô ; as is proved not only by stratigraphical evidence, but by the occurrence of pebbles of the easily recognised graphitic rock in conglomerates at Granville and other places which are themselves low down in the series. So that the horizon of these fossils seems to be somewhere near the middle of the pre-Cambrian sedimentary rocks of Brittany. Whether these rocks belong to the Huronian or to the Algonkian, or partly to one and partly to the other, there is no certain evidence ; but as they agree in mineral structure more closely with those of the Huronian of Canada than with those of the Algonkian, and as they contain numerous scales of graphite, they may be placed provisionally in the former period.

Dr. Cayeux's specimens have been examined by Dr. D. Rüst, and by Dr. G. J. Hinde, both highly competent authorities. Dr. Rüst, while allowing that they are organic, is inclined to think, from their small size and spherical shape, that they may be detached chambers of Foraminifera ; but Dr. Hinde upholds Dr. Cayeux's view that they are truly Radiolarians* ; and if we may rely upon the published figures, photographs of which I exhibit—and no one has thrown any doubt on them—they certainly appear to be Radiolarians and sponge-spicules. The figures of the Foraminifera seem more doubtful ; but as they are described as having finely perforated walls we cannot escape from the conclusion that they are true Foraminifera, and distinct from the Radiolarians which have coarsely perforated walls. The Foraminifera, however, are few, and consist of groups of simple spherules of different sizes which sometimes possess the rudiments of spines.

The Radiolarians are very minute, about one-fifteenth of the diameter of similar forms in Cambrian and younger rocks. Most of them have a thin spherical shell pierced with holes, and are sometimes furnished with spines ; but the forms are various. Twenty-four genera have been distinguished, two-thirds of which are still living, and there are many others, the genus of which cannot be determined, although they are unquestionably Radiolarians. By far the commonest forms belong to *Cerosphæra*, a still living genus, known also in the Silurian period, which belongs to the legion Spumellaria, the fundamental form of which is spherical or ellipsoid. But the legion Nassellaria, in which the fundamental form is ovoid, is also represented by nine genera, although the individuals are not so numerous as those of the first legion.

Sponge-spicules are probably common, but they are generally broken. They belong chiefly to the simple forms of Monactinellidæ, or to the Lithistidæ, or the Tetractinellidæ ; but a few fragments belonging to the Hexactinellidæ have been recognised.

* Geological Magazine, 1894, p. 417.

Many are of branched or radiate type, and they are surrounded by pyrites which probably represents the sponge. The fauna is, therefore, an extensive and varied one, and it is evident that both Radiolarians and sponges had existed for a long time when the series of Saint-Lô was being laid down. Even if they are wrongly referred to the Huronian period, this great variety of form may be taken as good evidence that the ancestors of these Radiolarians and sponges existed long before the Mollusca and Trilobites of the Algonkian period came into existence.

ALGONKIAN LIFE.

In Nevada and Utah on the west, and in Vermont and New Brunswick on the east of North America, as also in North-west India, the Algonkian beds are overlain conformably by the Cambrian; but in all other known places, not only in North America but also in Europe, there is an unconformity at the base of the Cambrian, thus distinctly separating the two systems.

In the rocks of Animikie, near Lake Superior, a shell something like *Lingula* as well as some obscure fragments of Trilobites and worm-like tracks have been found. In the rocks of the Grand Canyon of Colorado, where it passes through Arizona, Dr. Walcott has detected in a limestone, about 4,000 feet below the base of the Cambrian, abundant fragments of *Cryptozoön*, a genus—previously known from the Upper Cambrian—which differs from *Stromatopora* in having thinner and coriaceous laminæ without any connecting pillars or pores. Four hundred and fifty feet higher up he found a fragment of what seems to be the pleural lobe of a segment of a Trilobite; also a minute discinoid or patelloid shell and a small Lingula-like shell, possibly a *Hyolithes*. In North Vermont, at about 500 feet below the base of the Cambrian, he obtained fragments of a Trilobite and another so-called Pterpod—*Salterella*. In Conception Bay, Newfoundland, a patelloid shell—*Aspidella terranovica*—and worm tracks have been found in rocks underlying unconformably the Cambrian. And the Annelid (?) tubes of the Torridon sandstone in north-west Scotland as well, probably, as the worm burrows in the quartzites of Holyhead, in Anglesey, must also be referred to the Algonkian.

Just below the base of the Cambrian a more varied fauna occurs in two different parts of the world. In the Salt Range of the Punjab, Dr. Fritz Noetling has shown that there are four fossiliferous zones underlying the *Olenellus* fauna. These he calls (1) the *Neobolus zone*, (2) the Upper Annelid Sandstone, (3) the zone of *Hyolithes*, and (4) the Lower Annelid Zone. Also Dr. G. F. Mathew has described what he calls the *Protolenus* fauna from St. John, New Brunswick. It contains thirteen species of Trilobites belonging to six genera as well as Ostracoda. Six genera of pelagic Gastropoda, one (*Volborthella*) doubtful Cephalopod, seven of

Brachiopods, three of sponges, and two of Foraminifera. Dr. Mathew points out that the Trilobites of this fauna can be distinguished from those of Cambrian by having continuous eye-lobes, and he says that the fauna as a whole is more primitive and more pelagic in character than the *Olenellus* fauna.

Nevertheless, as the *Olenellus* fauna has not been found in the neighbourhood, he thinks it possible that the two might be contemporaneous, and that the difference between them may be due to difference in geographical station.

It appears, therefore, that out of the eight sub-kingdoms into which animals are divided by zoologists, six were represented in the pre-Cambrian times; but until we come close up to the Cambrian, the Protozoa and Porifera alone show much diversity, and they were certainly the dominant feature of the animal life of the early seas. No recognisable vegetable remains have been found in any pre-Cambrian rock, but pelagic algæ must have existed, for otherwise there would have been no food for the animals.

CAMBRIAN LIFE.

When we pass upward into the Cambrian period we find that life has made considerable progress, including the appearance of a new sub-kingdom—the Echinodermata; and in the Upper Cambrian we have the first Bryozoa and Pelecypoda. However, the only fossils which show much variety are the Brachiopoda and the Trilobites.

The Hydrozoa were represented by Sertularians, Graptolites, and Medusæ, the latter being so abundant that the National Museum at Washington has more than 8,000 specimens. These Cambrian Medusæ belong to a distinct family of the Discomedusæ called *Brooksellidæ*, and are distinguished by having a lobate umbrella without any marginal tentacles. It is remarkable that such soft things as jelly-fish should have been preserved as fossils; but although they have no hard parts, their tissues, when saturated with water, are sufficiently firm to make impressions on the mud or sand on which they have been thrown by the waves, and when the umbrella is turned upside down the gastric cavities get filled with the mud or sand and leave star-like marks, which are easily recognised. The Actinozoa are represented only by the curious *Archæocyathinæ*, which appear to be related to the perforate corals.

The hingeless Brachiopods were the first of their class to appear. According to Beecher, *Paterina* of the Lower Cambrian approaches nearest to the primitive stock, for it closely resembles the embryonic shell of later forms; and during the Cambrian period it gave rise to at least five different types of Inarticulata, one of which—represented probably by *Kutorgina*—led up to the Articulata, the first known of which, *Orthis*, had become well established in the Upper Cambrian.

Trilobites form by far the most important part of the fossil fauna, and can generally be distinguished by the shortness of the pygidium. Some were as much as 18 inches in length. The minute *Protocaris* of the Lower Cambrian is a Phyllopod with a sub-quadrate carapace.

The Cambrian mollusca are remarkable for the proportionately large number of elongated shells formerly classed as Pteropoda. Lately, however, many biologists have been led to the conclusion that the Pteropoda have had a comparatively late origin, and it is certainly remarkable that none are known between the Devonian and Eocene periods. It is now generally allowed that the *Hyolithidæ*, which includes all the pre-Cambrian and Cambrian forms, do not belong to the Pteropoda. They must, however, be considered as pelagic mollusca, and probably as the ancestors of the Cephalopoda. True Cephalopoda appeared in the upper Cambrian but did not attain any importance. Undoubted Gastropoda are represented by conical and spiral shells, all of which are very thin, and probably belonged to pelagic animals. The spiral shell is strongly in favour of these early Gastropods having been prosobranchiate, and this agrees with the discovery that some of the Opisthobranchs still inherit the twist in the visceral nerve-loop which is characteristic of the Prosobranchs. The early Pelecypoda were very minute, none of them being more than a quarter of an inch in length. The shells of all the Mollusca consist chiefly of a horny substance containing but a small quantity of phosphate of lime, and much less of carbonate of lime; thus differing from the later shells which are composed almost entirely of calcic carbonate.

No trace of a plant has been found in any of the Cambrian rocks unless *Oldhamia* and the Lower Cambrian oolitic limestones of South Australia* are proofs of the existence of calcareous algæ. *Eophyton*, which was formerly thought to be a plant, has been shown to be due to the trailing of the oral lobes of a Medusa over soft mud.

SPECULATIONS ON PRE-ORDOVICIAN LIFE.

Let us now see what these dry facts teach us. In the first place it is very remarkable that the only extensive pre-Cambrian fauna is composed of Radiolarians and Sponges; and as the Sponges are more complex animals than the Radiolarians we must suppose that they are descendent from them and not the Radiolarians from the Sponges; consequently the Radiolarians are the oldest organisms we know. No doubt the Radiolarians of Brittany are not the first of their class; nevertheless we seem to have got as near, perhaps, as we ever can get to the first organisms, and we find that they belong to a group which at the present day

* Pro. Linn., Soc. of N. S. Wales, vol. xxi, pp. 571 and 574 (1897).

floats near the surface of the sea. This pelagic aspect of the early faunas is carried out by the Mollusca of the Algonkian and Cambrian periods as well as by the great development of free-swimming Medusæ in the Cambrian; and we should remember that these delicate pelagic animals must have been very numerous to have left any record at all.

The earliest known Radiolarians are accompanied by the remains of sponges which must have lived on the bottom of the ocean, and these were followed by creeping worms and Trilobites. The early Brachiopods have diaphanous shells, like the pelagic mollusca, but it seems probable, from a study of their development in living forms, that at first they had no shell at all, but consisted of the peduncle encased in a sand-tube. The shell was afterwards added to protect the branchiæ, and in course of time the intestinal tract in the peduncle atrophied. Perhaps the so-called annelid tubes of the Torridon sandstone represent the first Brachiopods.

From all this we may infer that the first animals were pelagic protozoa which, in time, varied and gave rise to pelagic worms and mollusca. At a very early date, however, some of the protozoa followed down the dead organisms and settled on the bottom, giving rise to the sponges. Afterwards worms moved in the same direction, feeding, probably, on the sponges; and from them are descended the Brachiopods and the Crustaceans.*

The remains of the Brachiopods and Trilobites are found chiefly in shallow-water deposits, but some of them may have pushed their way into the deep sea, feeding on the dead pelagic organisms which rained down from above; indeed, it has been thought that the eyeless condition of some of the early Trilobites is a proof of this. But the eyes are always placed on the second segment, called the free cheek, and in several of the earlier forms this free cheek is ventral only, in which case no eyes could appear on the dorsal surface; the absence of eyes is not, therefore, always a proof of degeneration, but there are some species of *Paradoxides* in which it is said that the eyes have become rudimentary.

The hard spines of the early Trilobites could not have been for defence, for there were no enemies capable of attacking them; but, perhaps, they were used indirectly in locomotion. As their weak little legs paddled backwards and forwards in the mud the spines, all of which are directed backwards, would necessitate motion in a forward direction only.

There is no evidence of the existence of any animals sufficiently protected to live among the breakers round the shore, nor is there any evidence of life on the land. If a human spectator could have stood on the shore at that time he would probably have seen no

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* This theory was originated, I think, by Biologists, and was first brought prominently before Geologists by Professor W. K. Brooks, in the American Journal of Geology for July and August, 1894.

animal life at all. The rocks below low-water mark would be covered with delicate red and brown seaweeds, and the ocean between tide-marks would, then as now, be girdled with a belt of vivid green; but all the land above would be brown and barren, without even a moss or lichen growing on it. Upon the sands at his feet might lie a dead jelly-fish or Trilobite, or, perhaps, a delicate transparent shell thrown up by the waves; but they would be rarely seen, and the great ocean, although really swarming with minute life, would to the naked eye appear tenantless.

Did Plants Precede Animals?—It is generally supposed that plants must have preceded animals; for they alone are able to decompose the carbon-dioxide in the atmosphere, and thus furnish the carbo-hydrates and proteids on which animals feed. Or, in other words, plants must have preceded animals because they alone can live on mineral substances. But this supposition lands us in the difficulty of having to assume that the very first organism contained chlorophyll, which is necessary for the formation of protoplasm, but which is itself a product of protoplasm. This difficulty would be overcome if we could suppose that the primæval ocean, in which the first organisms appeared, contained, in addition to its present salts, mineral hydro-carbons which would slowly oxidise and supply the organisms with food without the necessity of decomposing carbon-dioxide. Now Professor H. Moissan has shown that much, if not all, of the carbon of the earth existed at first as metallic carbides, many of which are decomposed by water at ordinary temperatures, and yield hydro-carbons and hydrogen. Most of the hydro-carbons thus obtained are gaseous (acetylene and marsh-gas); but in some cases both liquid and solid hydro-carbons are formed abundantly.* The gases would be partly taken up by the water, while the liquid and solid forms would float on the surface, and if converted into carbo-hydrates may have served as food for the first organisms. It is, therefore, quite possible to suppose that protoplasm capable of secreting chlorophyll was a later development, when the supply of mineral hydro-carbons was getting exhausted, and consequently the first organisms may have been animals.

And now let me say a word about the origin of life itself. We have seen that it is highly probable that the first living organisms were evolved near the surface of a warm ocean, which contained abundance of carbo-hydrates and atmospheric air in solution, and which was agitated by the wind and other meteorological agencies—conditions which it would not be difficult to reproduce in the laboratory—and we may safely assume that the first protoplasm was not so complicated a substance as it has since become. Perhaps this does not help us much towards a

* Proceedings of the Royal Society of London, vol. 60, p. 156.

solution of the problem of the origin of life; for even if chemists* should show us how protein might be formed under the conditions just indicated, the important gap between dead protein and the simplest living protoplasm would still remain to be bridged. Nevertheless, we certainly have a clearer idea than we had before of the problem which has to be solved; and that is a step in advance. It is, indeed, the only step that can be taken by geologists.

ORDOVICIAN AND SILURIAN LIFE.

I will now pass on to glance at the life of the Ordovician and Silurian periods. The Ordovician was ushered in by the appearance of the highest sub-kingdom of animals, the vertebrata, reprepresented by minute teeth, called conodonts, from the green sands at the base of the Ordovician, near St. Petersburg. Fossils called conodonts have been found in various places, and in rocks of different ages, from the Upper Cambrian to the Carboniferous, but they differ much from one another. Some are, no doubt, the jaws of Chætopod worms; others are thought to be of crustacean origin, although no explanation is given of why these crustacean jaws should always be found dissociated from the other parts of the exoskeleton; possibly some may belong to Cephalopoda; but the conodonts, just mentioned, from St. Petersburg, have been shown by Dr. J. von Rohon to have enamel and dentine, with a pulp-cavity of an essentially vertebrate character, and this has been confirmed by Dr. Otto Jaekel; so that in all probability they belonged to lamprey-like animals, and if this is the case palæontology offers no support to Dr. Gaskell's ingenious hypothesis that the vertebrates are descended from the Merostomata.

In the Upper Ordovician of Colorado there have been found plates of an ostracoderm allied to *Asterolepis*, and true fishes are represented by enamelled scales, thought to resemble those of *Holoptychius*, and therefore to belong to the Crossopterygii, as well as by what appears to be the ossified chordal-sheath of a chimeroid fish. The late Professor Cope expressed a doubt as to the vertebrate origin of these fossils; but I have not been able to find that he has anywhere published reasons for his doubt.

The invertebrates which first claim our attention are the Graptolites and the Brachiopods. The Graptolites are known in North America from the Lower Cambrian to the Carboniferous, but in Europe they first appear in the Upper Cambrian as a monoprionidian form allied to *Dichograptus*. In the lowest beds of the Ordovician they suddenly attain their greatest devolpment, after which they gradually decline, and only a few forms pass into the Devonian. The earlier forms had many irregular branches, which

* Professor Liversidge informs me that some of the native mineral oils (Petroleum, Naphtha, etc.) contain oxidised compounds.

during the Ordovician period decreased in number, and became regularly arranged; while throughout the greater part of the Silurian we find only simple, unbranched forms. The thecæ also, which were at first straight and with straight apertures, became curved and with curved apertures often produced into a spine, and in the Silurian period the aperture was in some cases still more complex. The species of Graptolites are widely spread horizontally, and occur in very dissimilar rocks, such as limestones, shales, and grits. Sometimes they are accompanied by a varied fauna; but in other places they occur in thin zones without any other fossils, while the different species which characterise these zones are the same, and have the same vertical distribution, wherever they are found. The explanation of these facts appears to be that the Graptolites floated on the surface, and consequently were independent of the depth of the sea and the nature of the sea bottom. We find additional evidence in confirmation of this in the fact that some of the early species were furnished with a disc, which probably acted as a float.

The Brachiopoda show a remarkable development during both the periods under consideration. *Orthis*, in which the triangular opening for the peduncle remains open all through life, gave rise to the *Rhynchonellidæ*, which has a pair of deltidial plates in the opening, and to the *Strophomenidæ*, in which the opening becomes, during growth, entirely closed by a shelly plate, thus leaving the animal free. From the *Rhynchonellidæ* sprung, in the Silurian period, the *Terebratulidæ*, in which the deltidial plates remain separate, and the *Spiriferidæ*, in which they unite during growth, and close the opening for the peduncle, as in the *Strophomenidæ*.

All classes of the Mollusca increased greatly, especially the Cephalopoda, which are, after the Brachiopods and Trilobites, the most numerous of Silurian fossils. Now, too, we find, in the Lower Ordovician, thick-shelled Gastropods, and in the Silurian we have *Chiton*, an ancient form of soft-bodied mollusc, specially modified for protection among the waves of the shore. It has been suggested on very good authority—S. P. Woodward, H. von Jhering, and Professor A. Hyatt—that *Tentaculites*, and, perhaps, *Hyolithes*, represent the primitive Cephalopoda. Anyhow, it is highly probable that the first Cephalopods were pelagic in habit, for we know no ground-animals from which they could have been derived. These pelagic Cephalopods are but little known, and possibly some of the conodonts belonged to them. The ground Cephalopods appear first as Nautiloidea, which were very rare in the Upper Cambrian, increased rapidly in numbers during the Ordovician, and attained their maximum development in the Silurian.

The Arthropoda were now reinforced by the Eurypterida, in the Ordovician, and the Xiphosura in the Upper Salurian. The former were the largest and most powerful animals of their day,

attaining their maximum in the Silurian period, and becoming extinct before the end of the Palæozoic era.

Of plants we have at last certain knowledge. The first undoubted seaweed (*Buthotrephis*) occurs in Lower Ordovician rocks, while from the Silurian there are many beautifully preserved forms; from which we may infer that the Cambrian, and most of the Ordovician, seaweeds were too delicate in structure to be preserved. But in addition to seaweeds there were also land plants. In the Upper Ordovician, the extraordinary tree-like *Protoaxites* seems to have been a terrestrial Alga, while *Protostigma* is related to *Sigillaria*, and it is to *Protostigma* that the prickly macrospores from Bohemia, discovered by Dr. Rüst, probably belong. In the Silurian period there were two genera of *Lycopodiaceæ* (*Psilophytum* and *Glyptodendron*), and at least two genera of *Equisetaceæ* (*Annularia* and *Sphenophyllum*). Ferns, apparently, were not yet in existence, for the so-called *Eopteris* is now known to be nothing more than a growth of dendritic crystals.

Land Animals.—Rather above the horizon on which the first land-plants occur—that is, in the Silurian—the oldest known insect, *Palæoblattina douvillei*, has been found in France; and, although its affinities are rather uncertain, it is thought by Brongniart to belong to the Orthoptera. In the Devonian, neuropterous insects (May-flies) came on the scene; and in the Carboniferous there were many Orthoptera, Neuroptera, and, perhaps, Hemiptera. No other order of insects appear at that time to have been in existence. Scorpions, with stings at the end of their tails, like those of the present day, and, therefore, carnivorous, have been found in the Silurian, and spiders in the Carboniferous. The fact that carnivorous scorpions have been found as low down as the oldest-known phytophagous insect, is good evidence that insects must have existed on the land for some time previously; so that we may with some confidence refer their origin to the Ordovician period.

SPECULATIONS ON ORDOVICIAN AND SILURIAN LIFE.

The peopling of the shore-line and the land.—Probably all the different sub-kingdoms of animals had come into existence before the close of the Cambrian period. Henceforward no more fundamental types were to be introduced; multiplication and variation of the existing types was for the future to be the rôle, until all habitable parts of the earth were filled with life. It is in the early part of the Ordovician period that we first see animals fitted to live in the rough waters of the littoral zone of the sea-shore: these were thick-shelled gastropods, followed in the Upper Ordovician by the *Ostracoderma*. And it is in the Upper Ordovician that we have the first proofs of the existence of land-plants, followed in the Silurian by insects feeding on plants, and scorpions feeding on insects.

Rate of Variation.—When we think that certainly seven, and probably all eight, of the sub-kingdoms of animals were in existence before the close of the Cambrian period, it would seem at first that variation had gone on more rapidly during the earlier periods of the earth's history than afterwards; but this is an erroneous impression, due to the very unequal lengths of time represented by the different periods. Making every allowance for the possibility that the rate of denudation and depression may have been greater in past times than now, still we must admit that the relative thickness of the sedimentary rocks of each period is a rough measure of the relative length of time it represents; and I suppose that every geologist will agree that the Huronian, the Algonkian, the Cambrian, and the Ordovician were collectively at least equal in duration to all the periods that came after them—that is, they represent at least one-half of the time since life first appeared on the earth; but certainly the changes which have taken place in animals, and especially in plants, since the commencement of the Silurian period, are far greater than those that went before, both in the addition of new groups and in the extinction of old ones; so that the rate of variation must have increased and not diminished with time. It was this slow rate of variation in ancient times that enabled the early Palæozoic genera to spread so much more widely over the earth than do the genera of the present day.

Extinction of Groups.—The diminution or decay of a whole group of animals first began with the Graptolites in the Upper Ordovician, and they finally became extinct in the Carboniferous. The same process commenced with the Trilobites in the Silurian period, and they became extinct in the Permian. Can we trace any cause for this gradual process of decline in numbers? The existence in the earliest times of Radiolarians almost identical with their descendants of the present day is but another example of the persistence of types with which palæontologists have been familiar for a long time. It is true that we only know the hard parts of the ancient forms, but we have reason for thinking that if the soft parts had varied much the hard parts would have changed also. From the fact of the persistence of certain types it necessarily follows that there is no inherent necessity for organisms to vary or to decay, while the idea that if they vary then they must subsequently decay is opposed to the whole teaching of organic evolution, for it is the variable groups which have progressed. But if there is no internal necessity for decay, then the extinction of a whole group must be due to external agencies, and, if the group is widely spread, these agencies cannot have been local in their operation.

These external agencies may be changes in climate, or changes in the biological environment, due to the introduction of new

forms of animals, which may either prey on the older inhabitants or be successful competitors for their food supply. Change in climate may, perhaps, sometimes account for the extermination of a group of terrestrial animals or plants, but it cannot have a wide influence on those groups living in the sea, which must have perished either from violence or from famine. The struggle for existence with other animals has, no doubt, generally been the most efficient cause of extinction, and with Pelagic animals it is probably the only cause. At the present day, and during all the latter half of the earth's history, the struggle for existense has been so complicated that it is hardly possible to trace out its effects; but in the earlier times, to which this address refers, the problem was much simpler, and it may not be impossible to solve it.

The Graptolites were the first great group to suffer extinction. Pelagic in habit they could not have suffered more than other Pelagic animals from a change in climate. Living on the minute organisms which swarmed in the sea, and which they captured with their tentacles, we can hardly suppose that they succumbed to a want of food, and we are thus led to the conclusion that they must have formed food for others. Who were these others? They must have been either Medusæ or Pelagic Cephalopods, the owners perhaps of some of the conodonts, and of the two I should be inclined to choose the latter, but we know very little about them.

With regard to the Trilobites, Professor Walcott says that owing to their great differentiation the initial vital energy of the group became impaired, and that this was the cause of their extinction. With this I cannot agree, for the reason already given, and must, therefore, try to find some other and more efficient cause at work. As the Trilobites lived on the bottom of the ocean, where the temperature is uniform, we cannot invoke a change of climate as the cause of extinction, and there does not appear to have been any group of animals which could have been successful competitors with them for their food, for we know that they fed upon mud which no doubt contained numerous organic particles. So again we must have recourse to predaceous foes. This reasoning is much strengthened by the fact that in Ordovician and Silurian times the Trilobites had learnt how to defend themselves by rolling themselves up, a feat which the Cambrian Trilobites were not able to perform. Now the earliest powerful predaceous animals we know were the ground Cephalopods which first appearing in the Upper Cambrian rapidly increased in importance during the Ordovician and especially during the Silurian. The relative numbers of the Nautiloidea in these three periods being as 1 : 9 : 33, In the Cambrian and Ordovician periods the Trilobites had greatly increased, but in the Silurian they began to decline in numbers, and rapidly diminished during the Devonian

and Carboniferous, although a few lingered on to the Permian. This decline of the Trilobites coincides in time with the expansion of the Nautiloidea, and was, I have little doubt, caused by it. These ravenous Cephalopods, the precursors of our gigantic cuttle-fish, were the earliest rovers of the sea. Some lived near the surface and fed on Graptolites. Others sank to the bottom, where the inoffensive Trilobites had reigned for ages undisturbed quietly sucking mud. But the ruthless intruders turned the Trilobites over and tore out their insides in spite of their attempts to defend themselves by rolling up into a ball.

CONCLUSIONS.

We have thus arrived at the conclusion that the ocean was the mother of life. That on its surface floated the first organisms whose descendants, but little changed during all the millions of years that have since past away, still float and multiply. Presently some of these animals found their way down to the bottom, where all the debris from the floating organisms collected, and here, in still water, they lived and increased for a long time. Slowly they invaded the rough waters of the coast-line, and, at last, gained a footing on the land.

It was plants which formed the army of invasion that conquered the land. This army was followed by a mob of camp-followers and ragamuffins, in the shape of cockroaches and scorpions, who fed and fattened on the plants; but who, notwithstanding their boasted superiority, were quite incapable of reclaiming a single acre of desert. The real victory belongs to the plants, who, with undaunted courage, left the congenial water to dare the vicissitudes of temperature and moisture on land, and thus made civilisation possible.

No 1.—ON THE GLACIAL BEDS OF TOOLLEEN, COLERAINE, AND WANDA DALE.

By Evelyn G. Hogg, M.A.

(*Read Monday, January* 10, 1898.)

The areas described in the following paper are situate at Toolleen, Coleraine, and Wanda Vale, all in Victoria:—

TOOLLEEN AREA.

In the extreme north-west corner of the map attached to Mr. A. W. Howitt's paper on the "Diabase and adjacent formation of the Heathcote District," issued by the Department of Mines, Victoria, in 1896, part of the boundary of a glacial area is plotted. During the month of November, 1897, I visited this locality with a view

to ascertaining the exact nature and other boundaries of this area, no description of it occurring in Mr. Howitt's paper. The glacial area is situated a mile west of the township of Toolleen, 16 miles north of Heathcote; it is about 7 miles north of the glacial beds on the Wild Duck Creek, Derrinal, mapped and described by Mr. E. J. Dunn, F.G.S.* It lies at the north junction of the parishes of Crosbie and Weston, and penetrates into the south-west corner of the parish of Muskerry. It is irregular in shape, and covers, perhaps, a square mile in area.

The bed-rock of the locality is Lower Silurian, consisting mainly of sandstone. These are overlain to the north and west of the glacial area by beds of Pliocene age.

As compared with the neighbouring glacial area of Derrinal, that of Toolleen is disappointing. A careful search failed to reveal anything *in situ* which could be classed as glacial conglomerate; but the presence of erratics, striated, flattened, and grooved stones testify to the former presence of a glacial bed. The erratics are mostly of granite; but there are frequent blocks—rounded and flattened—of quartzite quite foreign to the district. The granites are of two kinds, both ternary, but one has a reddish felspar, the other a pink felspar with rather a larger percentage of quartz in its composition. They bear no resemblance to any granite in Victoria with which I am acquainted; but are similar in type to certain granite erratics found in the glacial beds of both Derrinal and Coimaidai. The largest boulder is partly buried in the ground; the mass protruding stands about 1 ft. high with a length of 3 ft. 6 in. and a breadth of 1 ft. 10 in.; none of the quartzite boulders have a volume greater than 1 cubic foot. Certain of the quartzites are apparently identical with those found in the Derrinal area. Striated stones were difficult to find; but some well-marked ones were secured. One is apparently identical with a striated stone collected by me in 1895 from the Derrinal area. There are a considerable number of stones lying on the surface which, though destitute of groovings, have that flattened and rounded appearance so typical of the normal striated stone.

This collection of erratics, foreign material, striated and flattened stones, is possibly the remnant of a northern extension of the Derrinal glacial area. Denudation has removed the accompanying till matrix until only the harder material has been left. There is reason to think that there has been a thinning-out of the glacial bed at its northern extremity here as elsewhere in Victoria. The boundaries assigned to the Toolleen area are those within which material undoubtedly foreign to the locality may be found.

In this context it may be mentioned that in 1895 I found granite erratics on the western fringe of Mount Ida, at a point

* Notes on the Glacial Conglomerate, Wild Duck Creek, by E. J. Dunn, F.G.S. Department of Mines, Victoria, 1892.

about $1\frac{1}{2}$ mile north of Heathcote. Several large ones may be seen in what was once the Mayfield vineyard, since destroyed owing to the presence of phylloxera. This spot is between 3 and 4 miles from the nearest boundary of the Derrinal glacial area, being separated from the latter by the intrusive diabase, and associated rocks described in Mr. Howitt's paper.

COLERAINE AREA.

The only reference I can find to any previous literature dealing with the glacial beds in the vicinity of Coleraine is a short paragraph in Progress Report (No. VIII) of the Department of Mines, Victoria, p. 59, by Mr. J. Ferguson, of the Department. In a paper on this district, read at the Adelaide meeting of the A.A.A.S., 1893, by Mr. J. Dennant, F.G.S., only the rocks of igneous origin were considered.

Before entering on a detailed description of the glacial beds, a word is necessary as to the general physical and geological features of the district. The country consists mainly of a plateau, at a level of about 700 feet above the sea, intersected by deep and wide valleys excavated by the Koroit, Koonong Wootong, and other creeks, the most westerly of which is McKinnon's Creek. The Koroit Creek, on which Coleraine is situated, flows south until about 2 miles east from Coleraine, when it makes a sharp bend, and takes a course which is approximately west until it passes out of the glacial area. The other creeks, of which the Koonong Wootong Creek is the most important, flow south into the Koroit Creek. The general level of the beds of these creeks is about 300 feet above the sea, and the valleys in which the creeks flow are very wide, with gently sloping sides for the most part. The plateau, therefore, north of Coleraine, to which the glacial beds are with one exception confined, may be regarded as divided into a series of roughly parallel tongues, pointing to the south, separated from each other by the creeks. The level of the plateau is reached about 3 miles north of Coleraine, where the uppermost beds are of recent Tertiary age. To the north and north-east of Coleraine the tongues of land terminate in a mass of igneous rock of a trachytic type. The greatest extension of the glacial beds lies between the Koroit Creek on the east, McKinnon's Creek on the west, the plateau to the north, and the Koroit Creek and belt of trachyte on the south.

On traversing the country between the creeks, striated and grooved stones may be found lying on the grassy surface every few yards; but only in three places can sections of the underlying beds in the glacial area be found. About 3 miles along the upper Koonong Wootong Road from Coleraine there is a cutting in which a bed of till is exposed, covered to the north by a ferruginous conglomerate or grit of Tertiary age. The cutting is on both sides

of the road, about 30 yards long, and having a maximum height of about 15 feet. It consists of a purplish soft clay, which in wet weather turns into a stiff mud on the exposed surface. It contains large numbers of striated and flattened stones and blocks of granite and quartzite, showing no signs of arrangement. No traces of stratification can now be recognised. The mean height of this cutting is about 650 feet above the sea level. About east 15° south from this cutting is a conical hill of olivine basalt, locally known as Adam. Through the northern face of this hill penetrates a dyke of trachyte running from west to east. This has been quarried out for building purposes, and at the eastern end of the dyke, and on its southern wall, the boulder clay is again exposed. It contains striated stones similar to those in the cutting just described; but the clay does not appear to have undergone any contact metamorphism. Having regard to its position with respect to the volcanic mass Adam, the absence of contact metamorphism from the dyke, and the general nature of the clay itself, I am inclined to think it owes its present position, banked up against the dyke, to a land-slip. The surface of a grassy slope rising from this outcrop in a south-westerly direction carries a large quantity of striated stones and foreign material. The exposure of boulder-clay on the side of Adam is at a level of 445 feet above the sea. The remaining outcrop of the glacial beds which I found in the district occurs on the railway-line as it passes over the northern slope of Mount Koroit, about 2 miles from Coleraine Station, at a level of about 400 feet above the sea. The cutting is nearly 120 feet long, and has a maximum thickness of 18 feet. The glacial bed here shown is identical with that exposed in the cutting on the Koonong Wootong Road, save that the boulders of granite found in it are of larger dimensions. The relation of the bed in the railway-cutting to the adjacent rocks is very obscure. It appears to occupy a pocket in the trachytic rock, which is exposed in the road just below, and occurs in large extension around it. Basalt, basaltic tuff, and a sanidine-bearing rock are all exposed not far to the east of the cutting. To the south and south-west of the cutting a large development of Mesozoic rocks occurs. On the eroded surface of the hill, lenticular patches of coarse sandstone covered by alluvium are seen. Stratification cannot be traced in the cutting.

The foreign material, either exposed in the cuttings or found lying on the surface within the glacial area, comprises coarse and fine-grained granite (the latter predominating), tourmaline-granite, quartz, quartzite, felspar and quartz porphyry, slate (unfossiliferous), and the fine-grained micaceous sandstones. The erratics are all of moderate size, the largest being a ternary granite.

With a view to ascertaining the age of the beds, a careful search was made for material similar to that of the surrounding rocks of igneous origin and for sandstones of a Mesozoic type. In no case

did I find included in the boulder-clay either of these classes of rock. With respect to the igneous rocks, it may be said that those of the trachytic type have a somewhat modern facies. The sanidine crystals in the specimens prepared for the microscope were, for the most part, in excellent preservation. With regard to direct evidence, the following extract from the paper by Mr. Dennant, previously referred to, may be quoted :—"An interesting discovery was made at the Mount Koroit outcrop. Almost at the top of the hill a shallow excavation of a few yards in diameter has disclosed a whitish felspathic tufa, small blocks of which now lie in the hollow. On breaking one of these blocks in two for convenience of transport, impressions of cycads were seen on both the fractured surfaces. Mr. Robert Etheridge, of Sydney, who has kindly examined some of the impressions for me, states 'that very little doubt can exist that the plant is a Mesozoic cycad, called Otozamites. It also occurs in the Queensland beds of a like age.' It should be mentioned that the sedimentary strata, amongst which these igneous rocks appear, are of acknowledged Mesozoic age."

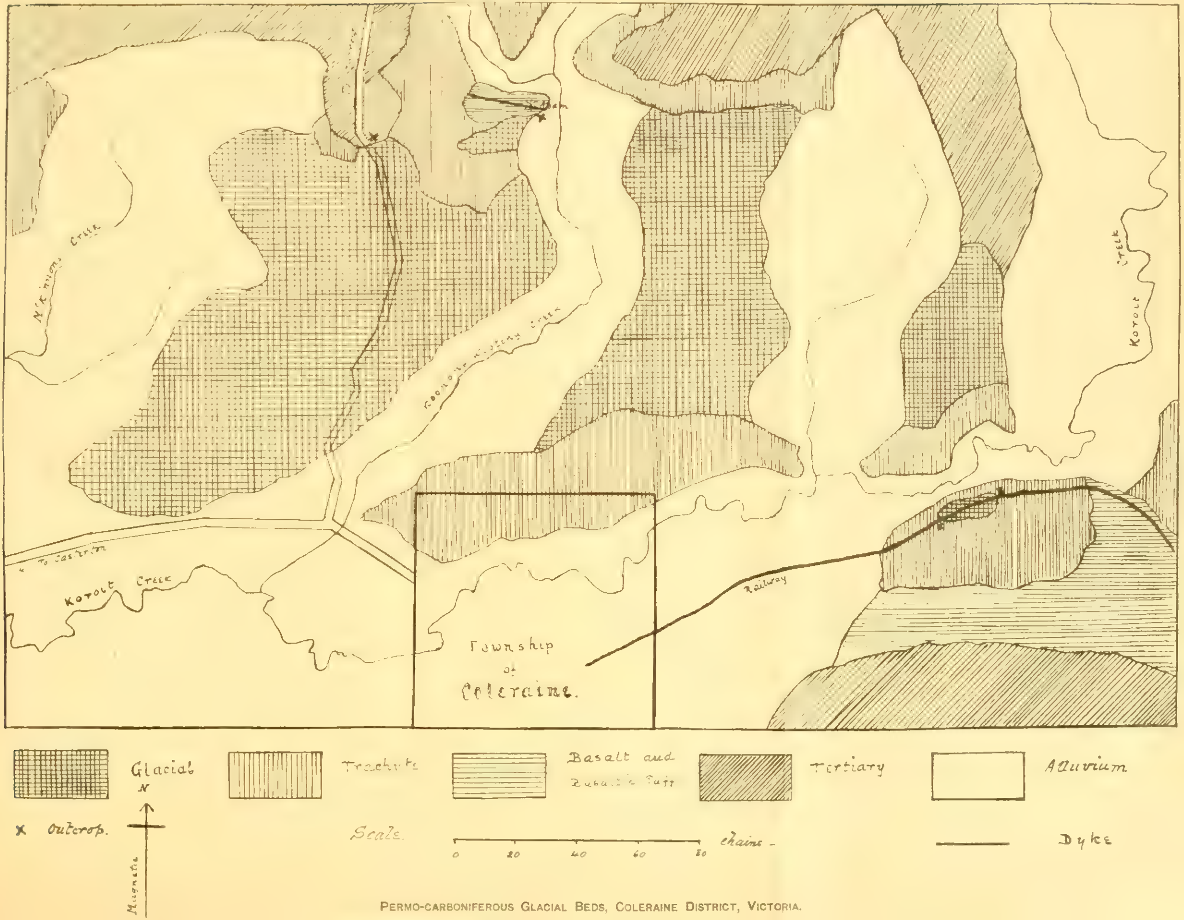
This bed of tufa lying at a higher level than the railway-cutting through Mount Koroit is, possibly, connected with the trachytic group, which occurs in the neighbourhood of Coleraine; but I am inclined to regard them as of later origin myself. It is scarcely probable that the volcanic cone Adam is of such antiquity, and between the trachytic dyke which penetrates it and the trachyte occurring east of the railway-cutting there is such a general resemblance of microscopic structure that it is hard to resist the conclusion that they are directly related to each other.

Having regard to the general character of the included material and to the absence of Mesozoic rocks—which cover a large area south of the glacial beds—it on the whole seems most probable that the glacial beds are of Permo-carboniferous age. If this is so, the absence from them of the local igneous rocks gives a lower limit as to the age of these latter beds.

The feature of the district is the wide area of grass-land over which striated stones, which have presumably weathered out of subjacent glacial beds, occur. If the age of the glacial beds be Permo-carboniferous, the underlying floor on which they were deposited is in all probability either granite or gneiss and schists of the metamorphic beds. Both of these rocks occur near Coleraine, and it is on the latter—gneiss—that the glacial outcrop at Wanda Dale subsequently referred to rests.

WANDA DALE AREA.

Wanda Dale Station, belonging to Mr. J. Moody, is situate about 12 miles N.N.W. of Coleraine, near the source of the Wanda River. In the bed of the river, at an elevation of about 700 feet above sea level, and about 1 mile west of the station, a deposit of



PERMO-CARBONIFEROUS GLACIAL BEDS, COLERAINE DISTRICT, VICTORIA.

glacial origin is exposed. It is very limited in area, being about 30 yards long; it occupies the whole width of the stream. At its eastern extremity it is seen resting on the upturned edges of the gneiss, which constitutes the bed-rock in this locality; its western boundary is a mass of igneous rock, which on microscopic examination is found to consist almost entirely of sanidine.

The actual junction of the two beds is unfortunately masked by alluvium and sand; owing to the amount of water in the river at the time I visited it any excavation to determine whether the clay was altered at the junction was out of the question. The bed consists of a light-brown and yellowish tough clay, through which small stones and boulders are somewhat scantily distributed. Most of the bed being under water, it could not be properly searched, but in addition to two well-marked striated stones I secured small boulders of ternary granite, quartz, quartzite, sandstone, and mica-schist. The sanidine rock was not found in the clay. The outcrop, though small, is interesting, as showing the northerly extension of the glacial beds of the Coleraine area, of which it must be I think regarded as an outlier. It may also afford a clue to the age of the igneous rocks which offer a problem of great complexity in this district.

No. 2.—FURTHER EVIDENCE AS TO THE GLACIAL ACTION IN THE BACCHUS MARSH DISTRICT, VICTORIA.

By C. C. Brittlebank, George Sweet, F.G.S., and Professor T. W. Edgeworth David, B.A., F.G.S.

(*Read Monday, January* 10, 1898.)

RELATION OF MATRIX AND BOULDERS TO LOCAL ROCKS.

Wishing to ascertain, if possible, the true nature of the Bacchus Marsh glacial deposits, some considerable attention has been paid to the relation of the boulders and matrix forming the glacial beds to the local rocks. This investigation was undertaken for the express purpose of discovering (*a*) If the Bacchus Marsh glacial deposits were a true till. (*b*) If of marine or fresh-water origin.

Mr. S. J. B. Skertchly says [evidently with the approval of Professor J. Geikie]: "There is a remarkable modification of the law that physical character of the boulder clay is dependent upon that of the subjacent rocks, a modification which evidently cannot be explained on the marine theory, nor yet on that of local glaciers. This is the invasion of the outcrop of one rock by the

boulder clay which is composed of some other rock." Accepting the above as being correct for the glacial deposits of the northern hemisphere, search was made for a spot where two underlying rock formations were of such a nature as to produce two entirely distinct boulder clays, had they at any time been subjected to invasion by land or sheet ice. As the section under notice is of some importance, a brief description of the contour of the underlying older rocks will not be out of place.

At 21 chains W. 30 degrees N. from the junction of the Myrniong Creek with the Werribee River there is an area of granite extending over several square miles.

As a large proportion of the above granitic area lies to the S.W. or in the direction from which the general ice movement took place, this, coupled with the physical features of the striated pavements, would lead one to conclude that had land ice passed over this area we should find evidence of the direction of its movement in the form of "tail," and also in the composition of the glacial deposits to the N., N.N.E., and E. Tracing the glacial pavement from the junction of the Myrniong Creek W. 30 degrees N. (about) for a distance of over 80 chains, we find the surface worn into three ridges with corresponding hollows. A distance of about 20 chains separates the ridges, and the greatest height of any ridge above the hollows along this section is 330 feet. The steepest face, however, is one in which there is a fall of over 150 feet in 5 chains.

From the junction of the Myrniong Creek and on the opposite side of the Werribee River to the above section, the older rocks (silurian and granite) rise abruptly to the S.S.W.; in fact at one time there must have been an exceedingly steep pre-glacial bank or cliff over which ice flowed or fell. (See Plate XVIII.) At the present time the slope rises 520 feet in less than 36 chains. At other points the rise is much sharper, but at these chaining was impracticable owing to the rough nature of the country.

The trend of this cliff is about W. 25 degrees N., and E. 25 degrees S., being about 35 degrees across the general direction of ice inflow. As the ice must have passed over the granite area for over 70 chains before flowing down the steep face or cliff, and as there are fine sections of glacial drift to the N.N.E., and E. (some of which are, as stated above, as much as 560 feet below the general surface of the granite area), careful search was made for any evidence of a true till or "tail" which one would expect to find on the lee-seite of the cliff. Although all the exposed sections to the N., N.W., N.E., and E. have been searched for boulders or fragments of local granite, the search has been without result, except in such places as those where fragments and blocks of granite are observed resting on the granite surface, or a few feet above it, where they are embedded in stratified

sandstone. In all cases where these local boulders have been observed, the surface of the granite rises at a sharp angle of from 20 degrees to 70 degrees.*

On close examination, the stratification of the sandstone can be traced up to the face of the boulders. In no instance have blocks of local granite been observed to the lee of the granite boundary. The matrix of the glacial drift situated on the lee of the granite area does not differ from the general character of that to the lee side of any silurian area, either in contained boulders or the matrix in which they are embedded, as far as can be judged from macroscopic examination. In certain places, however, a layer of several inches in thickness composed of rotten local granite can be observed resting on the granite base. Like the local boulders these patches occur at the foot of steep faces of granite, or along the bottom of pre-glacial hollows. A number of observations show that in no case, with the above exceptions, does the glacial matrix appear to be formed from local granite. In a number of places, more especially where the granite face is flat, or has a gentle slope, a thin layer of highly waterworn pebbles of various sizes and kinds up to three quarters of an inch in diameter, rests directly on the undecomposed glacial surface of the granite. Above the pebbles are the usual highly stratified sandstones and mudstones with bands of conglomerate formed of waterworn pebbles in which fragments of local granite are not represented. In a few places the grains of sand resting on the pebbles, and in direct contact with the granite face, are somewhat larger than those at higher levels; but in others, only a few chains apart, exceedingly fine stratified sandstone is in contact with the granite.

II. ABSENCE OF LOCAL BOULDERS.

After a search extending over several years for local boulders in the glacial deposit, one is forced to conclude that the occurrence of such is somewhat rare. During this period rock fragments, which could be classed as local, have not been found, with the exception of the granite blocks which occur on the bottom of pre-glacial gullies or at the foot of steep slopes or cliffs. On the other hand, many kinds of rock, a large percentage of which are supposed to be foreign to Victoria, are found in abundance.

III. ABSENCE OF UNSTRATIFIED GLACIAL DRIFT.

Perhaps one of the most striking features in the Bacchus Marsh glacial deposits is the almost total absence of unstratified material. This is the more inexplicable, as the other evidences of powerful ice action are present in a marked degree.

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* Speaking for himself, Mr. Brittlebank considers that they have probably fallen from a higher level.

Having examined the glacial beds which rest directly on the silurian and granite in the Bacchus Marsh district, one of us, Mr. Brittlebank, has been unable to detect any beds in which the stratification could not be made out. There are, however, beds of varying thickness. These appear to be unstratified, but they are generally intercalated with beds of fine silt and sandstone, with which they form an even junction.

IV. RE-ADVANCE OF ICE SHEET.

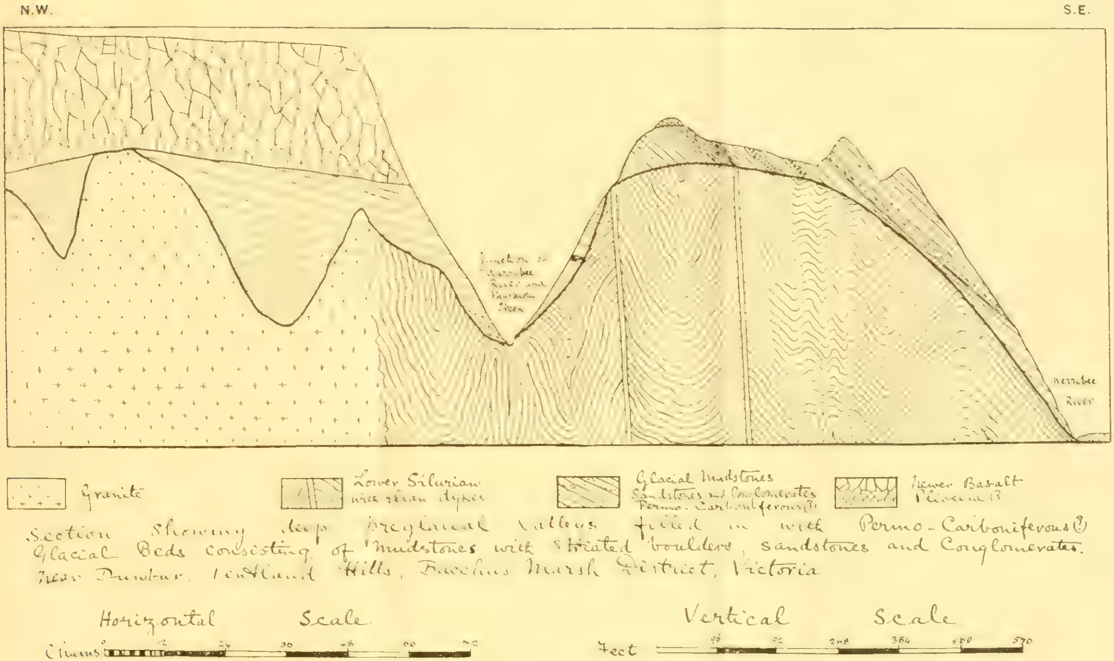
From sections given herewith, it will be noted that boulder beds occur at certain horizons, intercalated with beds of sandstone, silt, and conglomerate. As these might represent a return of a cold period or possibly a re-advance of an ice sheet, careful search was made along the junction lines for ploughing, contortion, injection, striated pavements, and other evidence of the passage of ice over the underlying glacial beds. With the exception of slight local contortion, no evidence has yet been observed by one of us (Mr. Brittlebank) which would support the theory of the individual glacial beds being due to successive ice sheets, alternately advancing and retreating. As, however, it has been shown that glacial ice can creep over incoherent beds without contorting them, this evidence cannot be held to be conclusive.

V. CONTOURS OF OLDER ROCKS AT THE TIME OF THE GLACIAL PERIOD.

As these naturally correspond with those of the present striated pavements observed in section in the Bacchus Marsh and surrounding districts, we have been able to obtain a fairly accurate idea of the old surface at the time of the glacial period, perhaps towards its close.

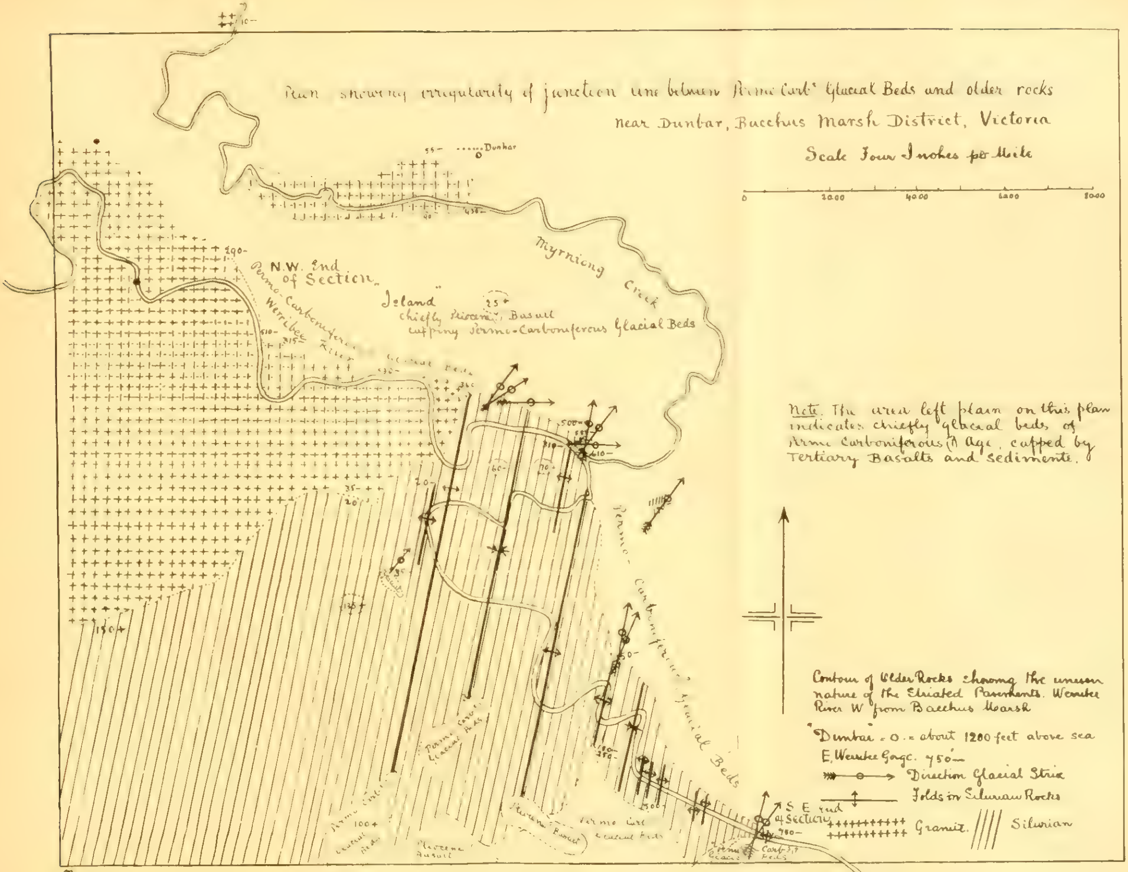
From the figures marked on the map some idea of the irregular surface may be gleaned [Plates XVII and XVIII]. We had hoped that from a careful study of this surface, and of the direction of striæ, we should have been able to express an opinion as to whether land or floating ice had formed the striated pavements and overlying deposits. From the conflicting evidence it would, perhaps, be premature at present to arrive at any but provisional conclusions.

The examination of the matrix of the Bacchus Marsh glacial beds, commenced by one of us, Professor David, has had to be postponed through his absence on the Funafuti Coral-boring Expedition. So far the examination for radiolaria and foraminifera has yielded negative results, though some obscure casts are slightly suggestive of the former having once been present, but this is very doubtful. Minute fragments of plants are, on the other hand, very numerous, and fairly well preserved. Minute chips of black shale, lithologically very like the local graptolite shales, are present in the matrix; and at Myrniong Creek, near Dunbar, the material forming the matrix of the glacial beds may very well have been derived from granite very finely pulverised. The comparative scarcity of large fragments of local rocks is nevertheless very remarkable, as already stated. No remains of diatoms have as yet been observed.



Glacial Action—Bacchus Marsh, Victoria.

By C. C. BRITTLEBANK, G. SWEET, and Prof. DAVID.



Glacial Action—Bacchus Marsh, Victoria.

By C. C. BRITTLEBANK, G. SWEET, and Prof. DAVID.

Speaking for themselves, Messrs. Sweet and Brittlebank regret that they have to take exception to some remarks made by Messrs. Officer and Balfour, at the Brisbane meeting of this association.

In reply, they would point out that the statements made by them at the Adelaide meeting are true in substance and in fact; this can, if necessary, be proved by correspondence which passed between Messrs. Officer and Brittlebank.

Mr. C. Brittlebank would also direct attention to an apparent slip made by Messrs. Officer and Balfour. They state that Mr. Brittlebank was the first to discover the true direction of ice-flow and interpretation of the Bald Hill sections. As Mr. G. Sweet was present on every occasion when these discoveries were made, Mr. Sweet's name should be associated with that of Mr. Brittlebank in connection with these discoveries.

No. 3.—NOTES ON THE GEOLOGY AND MINERAL DEPOSITS OF PORTIONS OF WESTERN AUSTRALIA.

By E. F. Pittman, A.R.S.M.

(Read Monday, January 10, 1898.)

No. 4.—THE EARLY HISTORY OF TIN.

By S. B. J. Skertchly, B.Sc.

No. 5.—THE PLEISTOCENE HISTORY OF NOTHERN ASIA.

By S. B. J. Skertchly, B.Sc.

No. 6.—THE BDELLIUM OF SCRIPTURE.

By S. B. J. Skertchly, B.Sc.

(Read Monday, January 10, 1898.)

No. 7.—THE ARTESIAN WATER-BEARING BEDS OF NEW SOUTH WALES.

By The Rev. J. Milne Curran, F.R.G.S.

(Read Tuesday, January 11, 1898.*)*

No. 8.—NOTES ON BONDI DYKE AND PRISMATIC SANDSTONE.

By R. L. Jack, F.G.S., F.R.G.S.

(Read Tuesday, January 11, 1898.*)*

No. 9.—NOTES ON THE PHYSIOLOGY OF THE PARISH OF ST. GEORGE, N.S.W.

By E. J. Statham.

(Read Tuesday, January 11, 1898.*)*

No. 10.—NOTES OF A GEOGRAPHICAL RECONNAISSANCE ON THE MOUNT KOSCIUSKO PLATEAU.

By The Rev. J. Milne Curran, F.R.G.S.

(Read Tuesday, January 11, 1898.*)*

No 11. — CONTRIBUTIONS TO THE GEOLOGY OF MOUNT KOSCIUSKO AND THE INDI-MONARO TRACK, NEW SOUTH WALES.

By A. E. Kitson, F.G.S., and W. Thorn.

(*Read Tuesday, January 11,* 1898.)

[*Abstract.*]

The following remarks embody a few observations made in the Kosciusko region, and the accompanying notes on the microscopical examination of typical rocks have been kindly supplied by Mr. A. W. Howitt, F.G.S., &c., to whom we desire to express our great indebtedness.

Several writers have referred* to the prevailing rocks on Mount Kosciusko as granites of various kinds. As pointed out previously by one of us,† the rocks at Monaro Gap are grey gneissic granite. With local variations, the granite of the Kosciusko Plateau, with its high parallel ridges, peaks, and tors, is of much the same character, though aplites of various kinds occur in several parts. The main plateau has an elevation of about 6,800 feet above sea level, and the ridges and peaks are from 100 to 250 feet higher. The tors are separated from one another by low, grassy saddles; and, in their great pillars and blocks, traversed by vertical and horizontal joints, furnish excellent illustrations of weathering. Echo Point, so named by us on account of the splendid echo there obtainable, is composed of a pretty, reddish aplite, and has a fine example of a rocking-stone. A saddle, 7,000 feet high, joining Mount Etheridge to Mount Kosciusko, the highest peak, divides the waters of the Snowy River, flowing north, from those of the Leatherbarrel Creek, running south into the Indi River. On the southern side of this saddle, under the eastern slope of Mount Kosciusko, and in a valley of the same name, lies a beautiful tarn, which we have named Lake Kosciusko. The mount itself consists largely of foliated granite, especially on its eastern side above the lake, where the rocks have high angles of dip and a northerly strike. Frost action is everywhere noticeable in the numerous massive blocks showing extensive fractures.

* "General Geology and Physical Aspect of New South Wales and Van Diemen's Land," by Count Strzelecki. "Researches in the Southern Gold-fields of New South Wales," p. 125, by Rev. W. B. Clarke, M.A., F.G.S. "Report by R. von Lendenfeld on the results of his recent examination of the central part of the Australian Alps," Sydney, Government Printer, 1885. "The Glacial Period in Australasia," by R. von Lendenfeld; Proceedings of the Linnæan Society of New South Wales, vol. x, Part I. "On the recently observed evidences of an extensive glacier action at Mount Kosciusko Plateau," by R. Helms; Pro. Linn. Soc. of N.S.W., 1893, vol. viii. "Geological Notes upon a Trip to Mount Kosciusko, New South Wales," by J. B. Jaquet, A.R.S.M., F.G.S.; Records of the Geological Survey of New South Wales, vol. v, Part III, 1897. "On the evidence (so-called) of glacial action on Mount Kosciusko Plateau," by Rev. J. Milne Curran; Proceedings of the Linnæan Society of New South Wales, 1897, Part IV.

† "Geological Notes on the Gehi and Indi Rivers and Monaro Track, Mount Kosciusko, New South Wales," Proceedings of the Royal Society of Victoria, vol. ix, new series.

Though the prevailing rocks are of granitic nature, the original sedimentary, but now altered, rocks are observable outcropping in several places. For instance, along the whole length of Kosciusko Valley they have been changed into highly siliceous and felspathic mica-schists, quartz-schists, micaceous hornfels and quartzites. They are much contorted, and some of them have veins and reefs of the white, vitreous and opaque quartz, so characteristic of schist areas. At the source of the Snowy River a large outcrop of very fissile, siliceous slates and quartz-schist occurs, and lower down the gorge these rocks are greatly contorted and splintered by dynamic agency. At various points in the bed of the Leatherbarrel Creek, in Kosciusko Valley, rocks of a similar nature may be seen, all dipping to the east, with angles varying from 54 degrees to 85 degrees. They are greatly jointed and in places overlain by large transported granite boulders. On the lip of the gorge, near where this creek plunges into the wooded valleys below, are several outcrops of highly-altered siliceous slates, siliceous and felspathic mica-schist, quartz-schist, fine-grained gneiss, and fairly massive quartzites. The last contain a large quartz reef, 3 to 6 feet thick, having the same general northerly strike as the strata which dip to the east, and east 20 degrees south, at angles varying from 73 degrees to 84 degrees.

The rocks in Kosciusko Valley are apparently connected with those at the Leatherbarrel ford by an intermediate series such as is found between the ford and Monaro Gap, and which probably exists higher up the Leatherbarrel Valley, thus forming a gradual transition from foliated granite through quartz-schist and indurated spotted slates to the phyllites and soft, fissile, argillaceous slates near the Leatherbarrel ford. The resemblance between the rocks at the ford and some of those in Kosciusko Valley appears at first sight very striking, but close examination shows the latter to be more highly altered, and the fissility of the original slates to have almost completely disappeared. The quartz, again, in the two areas differs only in the fact that in the former it possesses thin laminæ of argillaceous slate, while in the latter the corresponding laminæ consist of greenish mica, probably chlorite. In some cases the original sandstones have completely lost their clastic character, and have reached a more advanced stage of metamorphism than quartzites; in other cases they are slightly spotted and micaceous. The altered olive-green argillaceous slates are less decided in colour, and much more indurated, but otherwise resemble the typical olive-green phyllites of the Leatherbarrel Ford and the "Gehi Wall."

As already pointed out,* numerous dykes intersect this area, and these Mr. Howitt has determined as andesites and quartz—hornblende—and quartz—mica-diorites. Mr. Howitt's examination,

* "Geological Notes on the Gehi and Indi Rivers," &c.

which reveals signs of crushing in several of the rocks, shows clearly that the Kosciusko rock masses have been subjected to great earth stresses. Generally speaking, it seems that the oldest rocks were sedimentary ones of probably Ordovician age. These were intruded upon by granites of various kinds, which built up the major portion of the plateau. Subsequently numerous dykes of acidic and basic rocks, such as aplites, andesites, and diorites, were injected, and the greater part subjected to dynamic metamorphism, followed probably by later series of dykes. Thus the metamorphism has been of two kinds—contact and dynamic—the former altering the original sediments into quartzites, lydianites, porcellanites, &c., and the latter carrying the alteration further, and transmuting these into micaceous hornfels, quartz-schists, mica—and felspathic mica-schists, and perhaps gneiss, and the intrusive granite into gneissic granite and gneiss. The metamorphism, therefore, appears to have been similar to that which produced the interesting rocks found in certain portions of the Omeo and Dargo districts in Victoria, and described* by Mr. Howitt.

The question of glaciation has evidently been the most potent factor in stimulating geological research in this region. Several writers are of opinion that evidences of such action exist. Unfortunately, we were unable to examine any of the localities and deposits described by them, as our observations did not extend so far northwards, so can express no opinion regarding their main conclusions. In many places in the valleys we observed large masses of granite with polished surfaces, which at first sight appeared to be of glacial origin, but proved to be simply weathered joint and fracture planes. In other places, however, evidence of another nature seems to indicate ice action. On the south-western slope of Mount Etheridge lie numerous large and small pieces of altered sedimentary rocks, and masses of red and grey aplite, and granite. Many of the indurated and highly altered rocks are more or less smoothed, polished, and widely grooved. They are of both fine and coarse texture, and the latter only are devoid of joint planes which are quite different from the smoothed faces. On its western slope, and also lower down on the floor of Kosciusko Valley are great numbers of worn stones almost exclusively of altered sedimentary origin.

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*"Notes on the Physical Geography and Geology of North Gippsland," Quarterly Journal of the Geological Society, vol. xxxv. "The Diorites and Granites of Swift's Creek," Transactions of the Royal Society of Victoria, vol. xvi. "The Rocks of Noyang," Transactions of the Royal Society of Victoria, vol. xx. "The Sedimentary, Metamorphic and Igneous Rocks of Ensay," Transactions of the Royal Society of Victoria, vol. xxii. "Notes on the area of Intrusive Rocks at Dargo," Transactions of the Royal Society of Victoria, vol. xxiii. "Notes on certain Metamorphic and Plutonic Rocks at Omeo," Transactions of the Royal Society of Victoria, vol. xxiv, Part ii. "Notes on certain Plutonic and Metamorphic Rocks at Omeo, "Mining Department Quarterly Report, March, 1890. "Notes on the Rocks occurring between the Limestone River and Mount Leinster," Mining Department Quarterly Report, September, 1890. "Notes on the Contact of the Metamorphic and Sedimentary Formations at the Upper Dargo River," Mining Department Special Report, 1892. "Notes on the Metamorphic Rocks of the Omeo District," Report of the Australasian A. A. Science, Sydney, 1888. "Notes on the Metamorphic Rocks of Omeo," Report of the Australasian A. A. Science, Melbourne, 1890.

An interesting feature about these rocks is the occurrence on many of the harder and denser ones of a coating of what appears to be secondary silica which imparts a distinct glaze to them.

Again, much of the material in the banks of the Leatherbarrel Creek, lower down Kosciusko Valley, consists of angular and sub-angular fragments of altered rocks, with large slabs of the same intermixed, and appears to have been conveyed thither by other than ordinary fluviatile agency. On the other hand, there is an entire absence of any deposits which might be regarded as lateral moraines; neither did we see any satisfactory evidence of any *roches moutonnées*, perched blocks, boulder clay, or morainic débris.

The probable auriferous character of the region may be briefly alluded to. As it possesses features so closely resembling those of proved auriferous districts where both plutonic and metamorphic action have taken place, it is very likely that auriferous reefs will eventually be found near and at the contact of intrusive masses and dykes with the sediments, and also in both these and the plutonic rocks themselves. The district on the western fall from Mount Kosciusko, embracing the upper portions of the basins of the Gehi River and Snowy, Gehi, and Leatherbarrel Creeks as well as the Snowy and Kosciusko Valleys, is especially worthy of attention.

These observations were made during two visits to the mount, but each time adverse weather militated greatly against continuous or connected work being done.

NOTE.—Since writing the above, we notice that in a postscript to a paper (Proc. Linn. Soc., N.S.W., 1897, Part IV) on the so-called glaciation on Mount Kosciusko, the Rev. J. Milne Curran has evidently assumed that the original of this abstract dealt specially with that question. He is under a misapprehension, as only a small portion of it bore on glaciation, and the opinions held by us are herein concisely expressed.

No. 12.—NOTES ON SAMPLES OF ROCKS COLLECTED BY MR. A. E. KITSON AND MR. W. THORN.

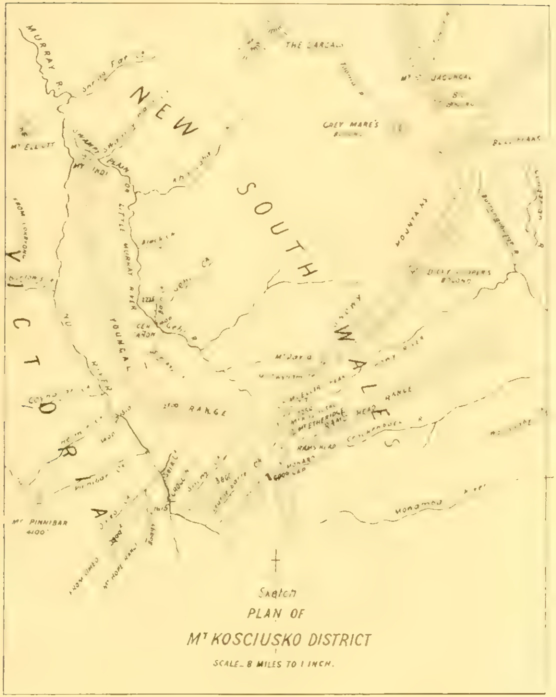
By A. W. HOWITT, F.G.S.

(*Read Tuesday, January* 11, 1898.)

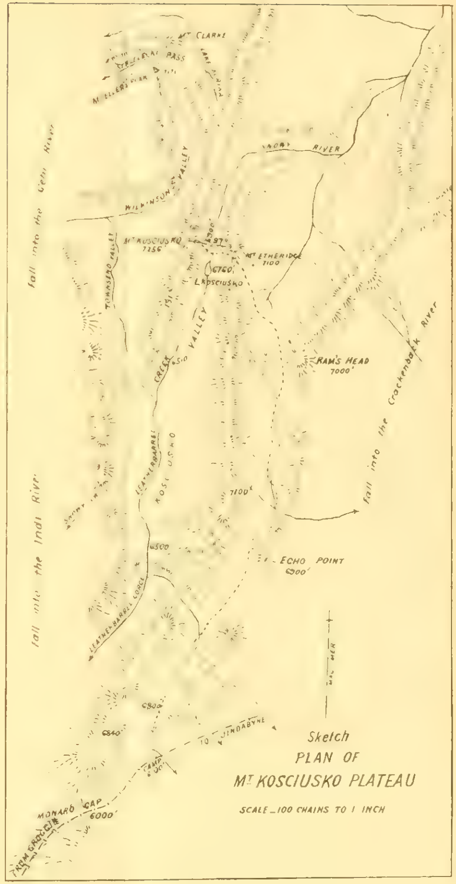
THIN slices have been prepared of a certain number of the rocks collected, and the following notes are the result of an examination of them under the microscope:—

I. Metamorphic—
   (1) Phyllite and fine-grained Nodular Schist.

II. Igneous—
   (2) Granitic-aplite.
   (3) Quartz Hornblende Diorite.
   (4) Andesite.



Sketch
PLAN OF
MT KOSCIUSKO DISTRICT
SCALE_8 MILES TO 1 INCH.



Sketch
PLAN OF
MT KOSCIUSKO PLATEAU
SCALE_100 CHAINS TO 1 INCH

Contributions to the Geology of Mt. Kosciusko, &c.

[*Note — Heights approximate only.*]

By A. E. KITSON, F.G.S., and W. THORN.

I. METAMORPHIC.

(1) *Phyllite and fine-grained Nodular Schist.*

The Phyllites and fine-grained nodular schists appear to pass into each other, indeed to be merely different stages in the metamorphism of fine-grained sedementary formations.

50. The former, as seen in this sample, is comprised almost wholly of mica flakes arranged in a linear manner, but scarcely forming foliations. They are extremely small, and are probably sericite. The only inclusions are minute black grains, which appear to be iron ore.

34. A further stage is shown where the rock is somewhat less fine-grained, the mica forming narrow foliations which include small "eyes" of radiating mica flakes. The rock is much permeated by black dust-like substance.

Among the foliations are grains of quartz arranged in places in a linear manner, and all more or less drawn out in the direction of foliation, so that their sections suggest a lenticular form.

19. The composition of the nodular schist is mica, in minute flakes and fibres (sericite), including much larger flakes of biotite, which is pleochroic in shades of yellowish brown. The biotite is arranged in lines indicating foliation of the rock. The only other constitutent of what may be spoken of as the ground-mass, are the plentiful grains of iron ore.

In this mass are "spots" which, although micaceous, differ in so far from it that there is no trace of schistosity, and that the amount of biotite in them is comparatively small.

The "spots" or "nodules" suggest, as was long ago pointed out by Professor Rosenbusch, that they represent portions of the rock substance which have been less completely metamorphosed.*

20. A further stage is where the rock-forming mica is of larger size, and the rock more decidedly schistose in structure. The alkali mica is in comparatively long flakes, and is colourless; the biotite is also longer, and is darker in colour, being pleochroic in shades of dark brown.

In parts there are discontinuous foliations of grains of quartz and mica. The "spots" are also more marked, being composed of distinct flakes of alkali mica, but still almost free from biotite.

23. 25. Samples still more marked in their microscopic foliated structure. There are foliations of Muscovite mica and biotite or of these together with quartz. In places, however, the quartz is discontinuous, but always lengthened in the direction of foliation. The "eyes" in these samples are very quartzose, but as in the other samples are almost free from magnesia mica.

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* Die Steiger Schiefer. Strasbourg, 1877, p. 178 *et seq.* Mikoskopische Physiographie der Massigen Gesteine, 1st part, 1895, p. 90.

A peculiar and probably exceptional form of schist is where epidote takes part in the foliated structure; the foliations being of mica, or of epidote and quartz with mica. In one part the slice is composed of somewhat larger crystals of epidote and quartz.

II. IGNEOUS.

(2) *Granitic—Aplite.*

41. This rock is peculiar in so far that the felspar is orthoclase, microcline, microperthite, and more rarely a plagioclase. These crystals are hypidiomorphic and set in a ground mass of quartz in interlocking grains. The plagiolase may be oligoclase, but the observations as to extinction in the zone P.M. were not conclusive.

The mica in this rock is in very small amount, in minute flakes, or aggregates of flakes, and is both muscovite and biotite.

43. In another sample the felspars as mostly microcline, more rarely orthoclase intergrown with albite veins, thus forming microperthite. The plagoclase is in hypidiomorphic crystals and obscures as under:—

$$\frac{\text{P.} - + \text{ to P. and M.} - \text{M.}}{4^\circ\, 40' - 16^\circ\, 40' - 22^\circ\, 58'}$$

With convergent light the trace of the exit of an optic axis is visible about the plane T and of a bisectrix on M. These felspars appear, therefore, to be albite. A considerable amount of quartz and very little mica complete this sample.

A series of samples illustrates the effects of crushing and of the production of a schistose structure in these aplites.

40. The felspars are of the kind already described, but in this sample are broken or somewhat rounded. The rock may be described as being composed of a ground mass of comminuted quartz and fragments of felspars. In this, which is the "mortar structure" of some authors, are embedded the felspar crystals, all being more or less broken or rounded off. Mica has also been produced and forms small foliations in the slice.

31. In places metamorphism has produced regeneration of material, orthoclase crystals being bordered and enlarged by micropegmatite.

26. A further stage is the production of a decidedly schistose structure. The rock has been considerably altered so that the felspars are much micacised, but it may be described as alternations of felspar, probably orthoclase and quartz in irregular foliations. Irregular layers of dark-brown iron-magnesia mica also fill in cracks and cıevices, and are clearly of secondary origin.

The quartz is in comparatively large fields, but almost always has cloudy obscuration.

This is one of the forms of schistose rock produced by metamorphism of an intrusive plutonic mass.

42. These are other instances of the formation of schistose rock composed almost wholly of foliations of quartz grains in some parts of very small size and characteristically drawn out. In parts small "eyes" of felspar are observable, usually surrounded by narrow foliations of alkali mica.

45. The contact of aplite and quartz schist is shown in one sample. The former is of the character already spoken of, orthoclase, microcline, and microperthite set in a mass of broken up quartz and felspar, with a little muscovite and biotite.

The quartzite schist is very fine-grained, the quartz-grains being, as elsewhere, drawn out so as to be longer than broad. Here and there are grains of orthoclase. Scattered through this, and also separating the lines of quartz-grains and thus producing a schistose structure, are numerous flakes of mica, mostly biotite.

This is one of those very quartzose fine-grained schists which I have observed to occur near the contacts of great plutonic masses and sedimentary rocks into which the former have intruded. I have observed and described* such a case between the Limestone River and Marengo Creek.

33. An extreme form of metamorphism appears to be when the aplite has been completely crushed and comminuted and then regenerated into a fine-grained micaceous schist, but with traces here and there of orthoclase crystals and with secondary quartz.

The rock has in such cases been so completely altered by metamorphism that it is only by the traces of felspar that it can be distinguished from a fine-grained mica-schist produced from a sedimentary rock.

(3) *Quartz Hornblende Diorite.*

28. This slice shows large broken and wasted crystals of hornblende of a yellowish-brown colour and with the ends in tints of blue. It is not strongly pleochroic in shades of dull green and yellow. I found the obscurations in two crystals to be 10° 42′ and 17° 56′ respectively. Biotite also occurs in smaller amount, and is somewhat bleached with elimination of magnetite.

The plagioclastic felspars are so much altered that no reliable obscurations could be obtained, but so far as they gave any results they suggested Labradorite. A smaller generation of these felspars is included in the hornblende.

48. In another sample the felspars were numerous and more or less ideomorphic but much converted into mica. The only obscuration angles obtainable were 22° 22′ and 21° 20′ on either side of the twin plane in the zone P.K., indicating Labradorite. Hornblende in this slice is plentiful but considerably broken and wasted. The obscuration in a section near to M., I found to be 16° 30′.

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* Notes on the Rocks occurring between Limestone River and Mount Leinster. Reports of the Mining Department, Victoria, September, 1890.

Andesite.

27. This rock is a network of narrow plagioclase crystals, the meshes of which are filled in by a light-yellow to pale-brown augite, and associated with this a considerable amount of ilmenite, much converted into leucoxene. The felspars obscured at angles of 18° 22′ and 19° 27′ in the zone P.K., thus indicating Labradorite.

The absence of olivine and the general character of this rock leads me to place it among those andesites which are very near to basalt.

51. One of the most interesting rocks in this collection is a holocrystalline compound of augite, amphibol, biotite, plagioclase, and orthoclase, the latter taking the place of a ground mass or of free quartz in more acid rocks.

The augite is in colourless hypidiomorphic crystals, which have been broken and eroded, and have a somewhat unusually well-marked prismatic cleavage.

The obscuration angles in a section near to M, I observed to be 42° 52′ in one part of the crystal, and 33° in another, the slice being somewhat inclined toward (100) $\infty \bar{P} \infty$.

There is a good series of augite crystals more or less converted into amphibole, the latter being very pale in tint, and having an obscuration of 12° 10′ on M, with a pleochroism in pale blue and pale yellow. These crystals have a narrow margin of chlorite.

The augite is also commonly intergrown with biotite, with which crystals of magnetite are associated.

The plagioclase crystals are hypidiomorphic, and are compounded according to the albite, Carlsbad, and more rarely the Baveno law. Measurements were not altogether satisfactory, but are given below. The exit of a bisectrix appeared in a slice approximately near the plane K.

Zone P. K. —	Zone P. M.
17° 59′	31° 43′
21° 47′	
29° 31′	

These observations point to a felspar of the Bytownite group.

The orthoclase is in considerable amount, and fills in comparatively large spaces, including other minerals, but especially plagioclase crystals. It thus takes the place of quartz as a residual constituent of the magma.

In only one part of the slice was I able to find a trace of cleavage in the orthoclase and in it obscuration was parallel.

The margin of the orthoclase was in most places edged by growths of micro-pegmatite, especially as it would seem where there were terminal planes formed. Outside these growths were again small amounts of quartz which appear to be of original formation.

The condition of this rock is surprisingly fresh and unaltered. In view of all these particulars I think that it may be placed provisionally among the andesites.

No. 13.—ON OLIGOCLASE FELSPAR FROM MOUNT ANAKIES, IN VICTORIA.

By A. W. Howitt, F.G.S.

(*Read Tuesday, January* 11, 1898.)

In studying the volcanic rocks of Victoria under the microscope, I have felt that the use of convergent polarised light might be made to give more conclusive results were it possible, in the first instance, to subject isolated crystals—for instance, of the triclinic felspars found in these rocks—to examination, and thus obtain data for reference.

Unfortunately, it is most difficult to obtain such crystals, and the only locality whence I have obtained them is Lake Purrumbete, in the western district; Mount Frankin, in the northern district; Mount Anakies, about 20 miles northwards from Geelong; and the Dargo High Plains, in Gippsland.

In order to ascertain what results might be expected from such an examination, I selected several isolated crystals of a triclinic felspar from a number which had been collected in the volcanic detritus at Mount Anakies. These crystals were in good perservation, and, although rounded on the edges and corners, the crystalline planes were readily distinguishable. The crystals were compounded of the planes P (001) OP., M (010) $\infty \breve{P} \infty$,— l (110) ∞ P′, P and T (110) ∞ P.

From each of four of these crystals three slices were prepared according to the planes P, M, l, and T, and also in a direction normal to P and M.

The samples selected for this paper are numbered I and II. In the three slices I determined the obscuration angles in P M and in the direction normal to P M with the following results :—

I. Seen in this slice according to P with crossed nicols there are numerous alternations of very narrow and of wider lamellæ, arranged according to the Albite law. In the slice normal to P and M there is not only the same synthetic structure—being, indeed, the continuation of the twin plates seen on P—but also a twining, as numerous and similarly arranged, according to the Perecline law, thus forming together a well-marked grating-like figure. Upon M this structure is not apparent. The observations made in slices of No. II were identically the same.

The obscuration angles measured in these slices are tabulated below, being the mean of a number of nearly agreeing readings.

No.	P	M	+ to P and M
I	+ 3° 7′	+ 12° 30′	+ 10° 0′
II	+ 3° 3′	+ 12° 19′	+ 11° 5′

Seen by convergent polarised light, there is upon P the appearance of a bar indicating the exit of a bisectrix beyond the field of view on the left. Upon M there is the exit of the positive bisectrix, and upon each of the planes l and T there is the well marked exit of an optic axis approaching to a normal position to those planes respectively.

These observations, which agree nearly in both samples, indicate a soda lime felspar of the oligoclase group. But the obscuration angles observed upon P appear to be somewhat high when compared with the data in a table prepared by Schuster.* An obscuration of 3° upon P and of 12° 30′ upon M may, however, be taken to indicate an oligoclase somewhat higher than the composition Ab. 6 to An. 1.

In order to have a control over these results, I obtained a quantitative analysis of the remainder of each sample, which Mr. Francis E. A. Stone, the Analyst to the Victorian Department of Mines, kindly made for me.

The two quantitative analyses are given below. Of the two, a preliminary examination showed that No. II was the more reliable, and I therefore made use of it, with the following results :—

	I	II	Remarks.
SiO_2	62·98	62·22	(1) Fe_2O_3–tr.
Al_2O_3...........	21·88 (1)	22·42 (1)	
CaO.............	2·78	3·34	
MgO	tr.	tr.	
Na_2O............	5·00	6·14	
K_2O	1·90	2·30	
Unestimated loss	5·46	3·58	
	100·00	100·00	

As to these analyses, Mr. Stone appended a note that in all probability they were rather low, as the laboratory did not possess the proper crucible for doing the fusions by Dr. Lawrence Smith's method. I calculated out the analysis into equivalent proportions, and found, in tabulating the results according to the formulæ for

* Hintze, Handbuch der Mineralogie, 1897, p. 1439.

allite and anorthite, that there was a deficiency of about 1·7, equal to ·9 per cent., of soda. Adding this in accordance with Mr. Stone's note, and recalculating back into percentages, the analysis closed with + ·12 per cent. of silica and − ·5 per cent. of alumina.

This calculation gave me a result of 84·10 per cent. of albite and 16·73 per cent. of anorthite as the composition of the felspar or ab. 5 to an. 1.

According to a table given by Dana (Min. 1892, p. 327) the percentages thus found are about 3 per cent. too high as regards the alkaline constituent.

The comparison of the optical and chemical examinations leaves the exact composition of this oligoclase in doubt in so far as relates to it being nearer to allite or to anorthite by one proportion of the former. But for all practical purposes, the observations of the obscuration angles, and of the position of the optic axial plane, appear to be sufficiently accurate to serve as a grade in diagnosing the character of a felspar observed in a thin slice of rock of the group to which the lavas of Mount Anakies belong.

No. 14.—NOTE ON THE OCCURRENCE OF FULGURITES IN THE SAND-HILLS AT KENSINGTON AND BONDI IN NEW SOUTH WALES: WITH A BIBLIOGRAPHY OF FULGURITES.

By G. H. Knibbs, F.R.A.S.; J. W. Grimshaw, M. Inst. C.E.; and Rev. J. M. Curran.

(*Read Tuesday, January* 11, 1898.)

Fulgurites, lightning tubes, or ceraunic sinters (Fr. fulgurites, pierres foudroyées; Ger. Fulguriten, Blitzröhren, Blitzsinter), as their name implies, are fused tubes or other fused structures, produced in sand, earth, or in rocks, by the action of lightning. They seem to have been first noticed by Pastor Hermann, of Massel,[1] Silesia, who, however, erred as to their origin, since he failed to recognise that the fusion was due to lightning. It was, notwithstanding, early known that lightning causes fusion, as the papers of de Fischer,[2] Buchholz,[3] Tillet and Desmarest,[4] and Alleon Dulac[5] indicate; and, in his papers on lightning and lightning conductors, Reimarus[6] mentions that the points of conductors occasionally melted during storms. In his Alpine travels between 1768 and 1789, Saussure[7] found small blackish

beads on the face of some slaty hornblende on the Dome de Gouté, obviously produced by the action of lightning.

The directness of the evidence as to the origin of fulgurites is, perhaps, best illustrated in the account given by Withering[8] in 1790, published in the Phil. Trans. of the Royal Society. On 3rd September, 1789, a tree was struck by lightning, and a man who had taken refuge thereunder was killed. At the point of his walking-stick a perforation, 2½ in. in diameter and 5 in. in depth, marked the place where the flash entered the ground. On digging, the soil was observed to be blackened for 10 in. more; 2 in. deeper again melted quartzose appeared, and continued in a sloping direction for 18 in. the fused material having run down the tube formed.

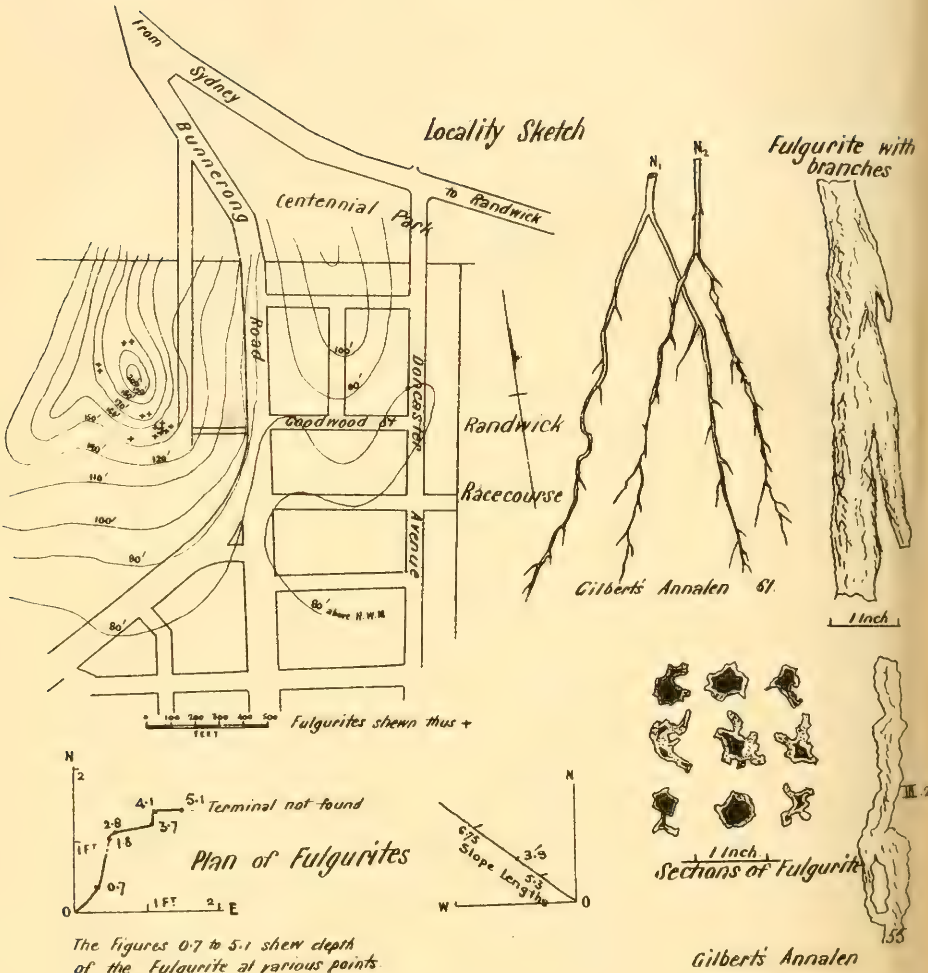
F. Humboldt[9] obtained some fulgurites in Mexico in about 1803, from the summit of a trachyte peak, about 15,000 feet above sea-level. The fused mass on the walls of the fulgurite had apparently overflowed. About the same year articles appeared in Moll's Annalen on "Kieselsinter;" one by Moll[10] himself, and the other by Emmerling.[11] In 1805 Hentzen[12] found a large number of fulgurites in the Senne Heath at Paderborn, Westphalia, to which he gave the name lightning-tubes (Blitzröhren), thus identifying, by name, these structures with their cause.

Hagen[31] reported in 1823 that his son had actually witnessed the striking of a birch by lightning. On digging beneath it the fused tubes were found.

In 1828 Beudant,[32] together with Hachette and Savart, made several small fulgurites artificially with powdered glass, and also with a mixture of powdered glass and salt, the latter being the more easily fused. The glass gave a tube 25 mm. in length, and with end diameters of about 3 mm. and 1½ mm., the interior diameter being about ½ mm. With salt added, a tube 30 mm. was obtained of an average diameter of 4½ mm., and an interior diameter of 2 mm. These tubes were produced by the most powerful electrical apparatus then available.

Evidently there can be no doubt as to the origin of fulgurites. It may be mentioned that the suggestion that these siliceous tubes are formed by other process than electric fusion, since roots are sometimes found in their interior, was disposed of by Fiedler[25, 27, 30] at the beginning of the century, and the matter does not now require serious discussion.

The occurrence of large numbers of fulgurites within an area of small radius led Darwin[34] to believe that they were often produced, not by lightning shocks at different times, but altogether. He concludes that, shortly before entering the ground, the lightning divides into separate branches, each forming a fulgurite. Probably they are so formed—that is to say, more than one is often formed at a single flash—that the photographs of flashes lend a strong



Fulgurites in the Sandhills at Kensington, N.S.W.

By G. H. KNIBBS, J. W. GRIMSHAW, and Rev. J. MILNE CURRAN.

support to this positive element of Darwin's view—is sufficiently indicated by the accompanying photograph taken by Mr. H. C. Russell, Government Astronomer. [A photograph kindly lent by Mr. Russell was exhibited.] The very numerous perforations of rocks, however, as, for example, on Little Ararat, reported by Abich[35] in 1869, is a sufficient proof that the same place is repeatedly struck. It is idle, therefore, to speculate, much more to dogmatise, on the question of the simultaneous production of any series of fulgurites.

The fulgurites at the Kensington Sandhills were discovered by J. W. Grimshaw, and those at Bondi by J. M. Curran, by noticing the small pieces broken off where the tubes, through the wind shifting the sand, had been left exposed. A little search then led to the discovery of the tubes themselves. They were dug out in the presence of two of us—J. W. Grimshaw and G. H. Knibbs—on two occasions, and J. W. Grimshaw and J. M. Curran on the other occasions. The bends and directions of the tubes were measured and are shown on the accompanying plate XIX, which also indicates the relative positions of the points where the tubes appeared on the surface. In form, the fulgurites are strikingly similar to those figured in plates 3 and 4, Band 55, and plate 4, Band 61, Gilbert's Annalen ; and one piece shows the branching off of smaller tubes, so well illustrated in the plates mentioned. (See plate.) The fulgurites are by no means perpendicular, one being inclined as much as 42 degrees with the vertical. They vary from about 5 mm. to about 25 mm. in diameter, the thickness of the walls being also variable, but generally from 1–2 mm. Outside the tubes is a well-defined ring of reddish sand, the thickness of the band being about 3 mm. ; the sand generally is siliceous, is quite free from calcareous matter, and is of a very pale yellow colour. A similar occurrence of reddish sand is noted by Fiedler (Gilb. Annal., Bd. 55, p. 133). In the opinion of one of us—J. M. Curran—this colour is derived by filtration from a stratum of limonite, which covered the sand-dune, and of which there is, in places, still a trace. Water passing through the limonite will, it is presumed, carry with it a small quantity of the hydrated ferric oxide ; this, trickling down the surface of the fulgurite, will strongly stain the sand immediately in contact. This view is not endorsed by another of us—G. H. Knibbs. In his opinion, the small trace of ferric oxide, to which the sand owes its yellow colour, was volatilised by the intense heat of fusion, and condensed in the sand immediately surrounding the fulgurite. There is no physical objection to this view, since even the heat of a porcelain furnace is equal, according to Elsner, to the task of volatilising ferric oxide. The distinctness of the boundary of the colour, a feature which is very striking, is urged as more consistent with the volatilisation than with the filtration view. Owing to

the extreme smallness of the interval of time concerned, the radiation of heat would be small, consequently the condensation would be concentrated about the tube itself.

The fulgurites from Kensington present no new feature as regards their form or general character. Externally they are rough, somewhat whiter than the surrounding sand; inside they are enamel-like, from the glassy surface of the fused silica. Under the microscope the fused material is seen to be full of small vesicles; the surrounding sand fused in the oxyhydrogen jet presents an almost identical appearance. In chemical composition the fulgurites are substantially the same as the surrounding sand.

Unfortunately, too great a mass of sand would have had to be moved to reach the terminals of the tubes. After following one for a length of 10 feet along its course, there appeared no indication of a change in size, and further excavation was impracticable. The photograph herewith [exhibited] and the exhibits give a definite idea of the form and characteristics of fulgurites formed in loose sand. The photographs were taken by one of us (J. M. Curran), and shew the section as well as a longitudinal view of the tubes.

The specific gravity of the fulgurite material was found to be 2·1, and its chemical composition by the analysis of one of us (J. M. Curran) to be SiO_2 93·4 %, Al_2O_3 5 %, Fe_2O_3 trace.

The somewhat lengthy bibliography of the subject, which here follows was prepared by one of us (G. H. Knibbs) with the view to forming a nucleus for a more perfect record. It is hoped that it includes at least the more important part of the existing literature on the subject, but since it has been somewhat hurriedly prepared, some papers have perhaps been missed. If any member of the section possessing references not included, will kindly allow them to be added, with proper acknowledgment, the bibliography will be correspondingly improved, and will more nearly achieve its object. [No addition has been made.]

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No. 15.—NOTES ON SOME NEW SOUTH WALES ROCKS.

By W. J. Clunies Ross, B.Sc., Lond., F.G.S.

(*Read Tuesday, January* 11, 1898.)

[*Abstract.*]

The rocks described were obtained from the Silurian country to the south of Bathurst, mostly from the neighbourhood of the mining village of Cow Flat. Near this place dolomite occurs associated with a white amphibole and a green chloritic mineral. Analysis of the dolomite shows carbonate of lime and carbonate of magnesia in the proportions of 55·6 and 43·73 per cent. respectively. The amphibole rock is fibrous and radiating, containing 55·2 per cent. of silica, 19·6 per cent. of lime, and 19·8 of magnesia, together with a little oxide of iron, and alumina. The green mineral has been examined microscopically and chemically. Analysis shows it to be essentially a hydrous silicate of alumina and magnesia. It is very soft and polarises under the microscope. A short distance from the dolomite extensive beds of limestone occur. Analysis shows these to be nearly pure calcite. At Bunnamagoo, about 15 miles south of Cow Flat, dolomitic limestones also occur. These have been analysed and shown to consist of carbonate of lime and carbonate of magnesia with a moderate amount of carbonate of iron.

It is believed that this is the first occasion on which either dolomite or chlorite has been noted in the Bathurst district.

No. 16.—NOTES ON THE AUSTRALIAN *TÆNIOPTERIDEÆ.*

By W. S. Dun.

(*Read Wednesday, January* 12, 1898.)

INTRODUCTION.

If we adopt the term *Tæniopterideæ*, in the original sense, for ferns with a certain type of venation, the range of the family is from the Carboniferous to the Recent. But it will be found that, as now generally used, the range of the family has been somewhat restricted, and is typically Mesozoic, a few species belonging to the type genus *Tæniopteris*, occurring in the Upper Coal Measures and Permian. The distribution of the members of the family is world wide, and the greater number of species are found in the Jurassic and Oolite. In Australia, as well as an imperfect specimen from the Greta Coal Measures, of Permo-carboniferous age, the family is found in great abundance through the fresh water Lower Mesozoic beds of ages corresponding to the Trias and Jurassic, and in the

Tertiary. Sir Frederick McCoy mentions a species from a Tertiary deposit at Dargo (*Tæniopteris tenuistriatissima*). In South Africa, India, and Eastern Australia the *Tæniopteris* Flora is just as well marked as the Lower Gondwana *Glossopteris* Flora that flourished during the preceding period, and the general facies of this Upper Gondwana Flora is very similar throughout these three regions, the remains of the old Gondwana Land. The Upper Gondwana Flora as well as the Lower is also well developed in South America.

The genus *Tæniopteris* was first erected by Brongniart in 1828* for the reception of some Palæozoic ferns. Since that time numerous other forms very closely allied in character to this genus have been found from beds of different ages, mainly Mesozoic, in all parts of the world, and it has been found necessary to modify the diagnosis of the family, and to form both genera and sub-genera, not only to make the original genus less cumbrous, but also to make the plants of greater stratigraphical value.

The classification most generally adopted as furthering these ends is that formulated by Schimper in 1869.† This author divided Fossil Ferns into five orders, of which No. IV is that of the Tæniopterideæ.

The ordinal characters are—"Fronds stipitate, simple oblong lanceolate, wide and elongate, entire [Feistmantel adds to this 'or dentate'] or pinnate; pinnæ linear or tongue-shaped, more or less pointed, with a short stalk or sessile. Rachis and primary veins stout, secondary veins springing at an acute angle, then becoming almost horizontal or oblique, simple and dichotomous. . . ." This order is founded on venation and includes the recent Marattiaceæ, Aspideæ, and Acrosticheæ. From their common relations to these three large living families, in which classification is based primarily on fructification, it will be seen how uncertain the relations of sterile fronds are. This matter is mentioned later on in connection with the genera.

The Tæniopterideæ include the following genera:—

1. *Tæniopteris*, Brongniart.
2. *Macrotæniopteris*, Schimper.
3. *Palæovittaria*, Feistmantel.‡
4. *Oleandridium*, Schimper.
5. *Angiopteridium*, ,,
6. *Marattiopsis*, ,,
7. *Danæites*, ,,
8. *Danæopsis*, Heer.

§ 9. *Phyllopteris*, Brongniart.
§ 10. *Megalopteris*, Dawson.
§ 11. *Lesleya*, Lesquereux.

* Prod. Veg. Foss., pp. 61-62.
† Traité Pal. Veg., i, p. 600.
‡ Pal. Indica, Gondwana Flora, ii, 1876, p. 12.
§ These are not mentioned in Schimper's work.

Of these we are mainly concerned at present with 1, 2, 4, 5, 8, 9, and these alone will be dealt with, in the order named.

GENERA.

1. Tæniopteris.

Brongniart defined this genus as Ferns possessing "simple leaves, entire, midrib thick and stiff, veins perpendicular, simple or forked at the base. Fructification in the form of punctæ." Since this, as above stated, the genus has been considerably modified by Schimper, who restricts the name *Tæniopteris* to the Carboniferous and Permian forms with the following characters:—"Fronds simple, scolopendriform. Primary nerve (rachis) channelled on the upper surface, beneath almost smooth, strong; secondary nerves very clear, delicate, close together, somewhat dichotomous towards the base, nerves simple or dichotomous, parallel simple nerves, not infrequently mixed with the divided ones. Fructification unknown."‡

On the other hand, however, Mr. A. C. Seward, in his "Fossil Plants of the Wealden,"* defines *Tæniopteris* as ferns possessing "Frond simple or pinnate, usually lanceolate or linear lanceolate, apex acute or occasionally obtusely terminated; a well-marked midrib from which lateral veins are given off either at right angles or more or less obliquely; these may be unbranched or acutely forked as they pass towards the leaf margin." He proposes to use *Tæniopteris* in the same broad sense as Nathorst,† including under the one comprehensive term *Oleandridium*, *Angiopteridium*, *Marratiopsis*, *Danæopsis*, *Macrotæniopteris.*

So far as we know at present no Palæozoic *Tæniopteris* has been described from Australia. In the collection of the Mining and Geological Museum there are two imperfect specimens of a fern showing a well-marked midrib, veins running obliquely to the margin, no anastomosis and only infrequent furcation, apex and base unknown. It is very probably that more perfect specimens will show this to be *Tæniopteris.* It is from the Greta or Lower Coal Measures and the fragments are contained in a portion of the core of the Rutherford Bore.§

2. Macrotæniopteris, *Schimper.*

(Traité, Pal. Vég., 1869, i, p. 610.)

Sp. char.—Fronds simple, handsome, more or less broadly elongate-lingulate, obtuse or acuminate, entire, rarely irregularly divided pinnately. Fructification of the Aspideaceæ type.—*Schimper.*

* Pt. 1, 1894, pp. 122-125.

† Floran vid Bjuf, 1878, pp. 44-48.

‡ Traité Pal. Vég., i, p. 600. *See* also Zeiller, "Etudes sur le Terrain Houiller de Commentry," ii, 1888, p. 279. (Bull. Soc. Ind. Minerale, Ser. 3, ii, Pt. 2.)

§ Since this paper was read, Sir Frederick McCoy has described *Tæniopteris Sweeti*, from the *Gangamopteris* beds of Bacchus Marsh. (Procs. R. Soc. Vict., 1898 (N.S.), pt 2, pp. 285-286.)

The leaves of this fern resemble those of the Australian *Asplenium* (*Neottopteris*) *nidus*.

In Zittel's Paleophytologie, Schimper gives a fuller description: "Fronds simple, sometimes more than two feet long and six inches wide; ribbon-like, apex rounded or slightly pointed; they appear to have had a membranous consistency; lateral veins springing at an acute angle, then sharply curved towards the margin or almost horizontal, the upper ones only oblique, bifurcate at the base or simple, close together."

Range.—Keuper—Oolite.

4. Oleandridium, *Schimper*.

(Traité Pal. Vég., 1869, i, p. 607.)

"Fronds simple, lanceolate-elongate or tongue-shaped, coriaceous. Fructification similar to that of the Aspideaceæ."—*Schimper*.

Distribution.—Mesozoic-Tertiary. Recent ally, *Oleandra*

5. Angiopteridium, *Schimper*.

(Traité Pal. Vég., 1869, i, p. 602.)

In this subdivision of *Tæniopteridæ* the fronds are pinnate, with articulated pinnules, deciduous. The sori are transversely convex and linear, marginal.

This genus is very like the recent *Angiopteris*. The pinnæ are typically long and strapshaped. The genus commences in the Trias and ascends to the Tertiary.

Distribution.—Lower Mezozoic. Recent ally, *Angiopteris*.

6. Danæopsis, *Heer*.

(Schimper, Traité Pal. Vég., i, p. 613.)

In his first work, Schimper placed this under the Tæniopterideæ, and was followed by other writers on the genus. In his contribution to Zittel's Paleontologie, however, it is removed from that position and placed under the Marattiaceæ, which he makes to include the following fossil forms showing fructification *Marattia* (Rhætic and Lias, Recent), *Danæites* (Upper and Lower Cretaceous), *Danæopsis* (Keuper and ? Permian, sterile fronds), and *Danæa* (Lias). He defines the genus in these words "Fronds very large, petiole thick, simply pinnate, pinnules large, rather far apart from one another, connected to one another at the bases

springing at an acute angle, ribbonlike, contracted gradually towards the apex; midrib strong, lateral veins springing at an acute angle, then incurved and running a little obliquely towards the margin, some simple, others forking at the point where the curvature commences; sporangia arranged in close series to the margin, rounded, opening by a perpendicular slit (?) as in the genus *Angiopteris*, or by a pore (?), as in *Danæa*."—*Schimper*.*

Fertile fronds have been found in the Lower Keuper, sterile in the Trias and Lias. One species, *D. Hughesi*, Feist., is particularly abundant in the Rajmahal beds of India.

From Australia no species has been described as yet, but some specimens from the Narrabeen beds of Turrimetta Head may prove, on further investigation, to be new. In connection with this New South Wales form and the Indian *D. Hughesi*, the great similarity in the form of the pinnules and the venation to some of the lanceolate-pinnuled species of *Thinnfeldia* is remarkable, the sole tangible difference being the greater size of *Danæopsis*. I venture to think, in contradistinction to the late Professor Feistmantel, that the relationship between the Indian species, even as proved by his own figures,—which show at the basal portion of the frond small lobate pinnules, similar in every respect to those of *Thinnfeldia*,—is much closer, in the absence of fructification, to *Thinnfeldia* than to Heer's *Danæopsis*. This matter will be discussed at greater length in the description of the Narrabeen plants.

Phyllopteris, *Brongniart*.

(Tab. gen. Veg. Foss., 1849, p. 22.)

Sp. char.—"Fronds or pinnæ of the fronds more or less lanceolate, margin entire, midrib becoming thin towards the apex; secondary nerves springing from the midrib continued in an oblique direction, curved, often furcate and anastomosing with one another.—*Saporta*."†

By many authors species of this genus have been referred to other genera, mainly *Sagenopteris;* but, in opposition to this, Saporta says: "The obliquity and also the curvature of the secondary veins, which are very numerous and branched and dichotomous, but not anastomosing so as to form a net structure, distinguishes the genus *Phyllopteris* from *Tæniopteris*, on one hand, and *Sagenopteris* on the other."‡

Range—Rhætic—Oolite. One species occurs in the Leigh's Creek beds of South Australia, and also in the Ipswich Formation of Queensland.

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* Zittel's Pal., Palæophytologie (French Trans.), p. 86.
† Saporta, Pal. Franc Pl. Jurassiques, 1873, i, p. 448.
‡ *Op cit.* p. 449.

RELATIONS.

As the members of this family are classed mainly in accordance with their venation—the *Nervatio Tæniopteridis*—it is on this factor that most stress must be laid in comparing them with recent ferns. Amongst these we may select immediately the genera *Oleandra, Scolopendrium*, and *Marattia, Danæa, Acrostichum, Olfersia, Lomariopsis, Gymnogramma (javanica), Asplenium (nidus), Vittaria*, members of the recent Polypodiæ, Asplenia, Aspideæ, and Marattiaceæ. This will serve to prove the late Marquis de Saporta's statement that the exact definition of the Tæniopterids, properly so-called, constitutes one of the difficulties of Palæobotany.* Of the chief references given below,† the most important and recent is that by Mr. David White, who discusses very fully the evolution of *Neuropteris, Alethopteris*, and *Tæniopteris*, this last through *Megalopteris* of the Devonian, from what he terms the *Megalopteris*-stock. It would be impossible to do justice to this author's views in any other words but his own; and I venture to quote his concluding remarks: "According to this hypothesis, we may suppose that the pinnate Tæniopterideæ, or a portion of that group (without prejudice of any important systematic distinction between the pinnate and simple forms) came from an early *Megalopteris*-stock, probably through the alethopteroid forms. The earliest flora, so far as I know, in which any of these occur, that of the Middle Devonian at Saint Johns, New Brunswick, besides containing the *Megalopteris Dawsoni*, has also representatives of *Neuropteris*, most of which are alethopteroid, and of *Alethopteris*, including the *A grandis* and *A discrepens* already referred to. It is not improbable that the three of these genera originated in a common stock; and since the *Megalopteris* group offers a comprehensive type from which the *Neuropteris* and *Alethopteris*, as well as the known *Megalopteris* species, might well have descended, that name may conveniently be employed in the hypothesis to designate the type existing previous to the Middle Devonian, from which the neuropteroid, alethopteroid, and tænioptcroid, including in the latter some species of living Marattiaceous genera, descended." In connection with *Megalopteris* it may be mentioned that Solms Laubach considers that there are, in his opinion, no grounds for considering that these are anything but Ferns, in contradistinction to the views held by Saporta and Marion who considered them to be close to the Dolerophylleæ, which are classed by Schimper as next to the Cordaiteæ.‡

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* Saporta, Pal. Franc., Pl. Jurassiques, 1873, i, pp. 430-435 *et. seq.*

† Seward, Foss. Pl. Wealden, 1894, i, pp. 122-125.
Solms-Laubach, Fossil Botany, Eng. Trans., 1891, p. 136.
Schimper, in Zittel's Traité de Paléontologie (French Trans.), pp. 128-130.
Feistmantel, Pal. Indica, Gondwana Flora, ii, 1880, pp. 9-14.
White (D.), Bull. Geol. Soc. Am., 1893, iv, pp. 119-132.

‡ Solms Laubach, *Op. cit.*, p. 126.

AUSTRALIAN SPECIES.

4. Angiopteridium spathulatum, *McClelland.*

(Tæniopteris (Angiopteridium) Daintreei, *McCoy.*)

Tæniopteris Daintreei:—

McCoy, Trans. R. Soc. Vict. for 1860 [1861], v, pp. 96-107, 215-217; Procs., p.x.

Clarke (W. B.), Trans. R. Soc. Vict. for 1860 [1861], v, pp. 89-95, 209-214.

McCoy, Intercolonial Exhib. Essay, 1861, p. 166.

Hochstetter, Verhandl. K.K. Geol. Reichsanstalt, Jahrb., 1861, xii, p. 28.

McCoy, Ann. Mag. Nat. Hist., 1862, ix, p. 143.

McCoy, Ann. Mag. Nat. Hist., 1867, xx, p. 196.

Wilkinson (C. S.), Geol. Rept. Cape Otway District, 1865, p. 22.

McCoy, Rept. Westernport Coalfields, 1872, p. 6.

McCoy, Prog. Rept. Geol. Survey Vict. (Smyth's), 1874, p. 35.

McCoy, Prod. Pal. Vict., 1875, ii, p. 15, t. 14, f. 1-2.

Feistmantel, Records Geol. Survey India, 1876, ix, Pt. 4, pp. 122-124.

Feistmantel, Pal. Indica (Gondw. Flora i), 1877, Ser. ii, No. 2, p. 95; Pt. 4, p. 207.

Etheridge, R. junr., Cat. Austr. Foss, 1878, p. 100.

Feistmantel, Palæontographica, 1878, Suppl. Bd. iii, Lief. 3, Heft 1, p. 110, t. 14, f. 2, 3; *Op. cit.*, 1879, Heft 2, p. 169, t. 12, f. 5.

Pittman (E. F.), Ann. Rept. Dept. Mines, N. S. Wales, for 1879 [1880], p. 372.

Tenison Woods (J. E.), Procs. Linn. Soc., N. S. Wales, 1883, viii, p. 117.

Wilkinson (C. S.), Notes on Geol. N. S. Wales (Mineral Products), 1882, p. 55; Ibid, 2nd Edition, 1887, pp. 71, 72.

Johnston (R. M.), Procs. R. Soc. Tas., for 1885 [1886], p. 375.

Feistmantel, Sitz. K. B. Gesell. Wissens., Math.-Naturw. Cl., 1888, p. 630.

Feistmantel, Abhandl. K. B. Gesell. Wissens., Math. Naturw. Cl., 1890, Folge vii, Bd. 3, p. 66, t. 2, f. 11.

Feistmantel, Mem. Geol. Survey, N. S. Wales, Pal. 3, 1890, p. 114, t. 27, f. 4, 5; t. 28, f. 6, 6a.

Etheridge, Ann. Rept. Dept. Mines N. S. Wales for 1889 [1890], p. 237.

Etheridge, Ann. Rept. Dept. Mines N. S. Wales for 1891, p. 269.

David (T. W E.), *Op. cit.*, p. 221.

Etheridge, Geol. and Pal. Q'land, 1892, p. 371.
McCoy, in Stirling (J.), Reports on Vict. Coal-fields, Dept. Mines Vict., Spec. Repts., 1892, p. 12, t. 2, f. 11, 12.
Etheridge, Ann. Rept. Dept. Mines N. S. Wales for 1892 [1893], p. 172.
Pittman (E. F.), Ann. Rept. Dept. Mines N. S. Wales for 1895 [1896], p. 121, 122.
Pittman (E. F.), and David (T. W. E.), Mem. Geol. Survey N. S. Wales, Pal. 9, 1895, p. xi.
Dun (W. S.), Ann. Rept. Dept. Mines N. S. Wales for 1895 [1896], p. 188, 189.
Dun (W. S.), Ann. Rept. Dept. Mines N. S. Wales for 1896 [1897], p. 153.
T. spatulata, McLelland, Shirley; Add. Foss. Flora. Q'land, 1897, p. 27.

This fern was first described by Sir Frederick McCoy, in 1875,* with the following diagnosis:—"Frond very long, linear, parallel-sided, substance thick, edges straight, midrib thick, very strong; veins extending at right angles from the midrib to the lateral margins, a few straight and simple, the greater number once forked at a variable distance between the midrib and lateral margin. Usual width of frond, 4 lines; about 10 or 11 lateral veins in the space of 2 lines at the margin (both of ordinary specimens, 4 lines wide, and one young fragment nearly 2 inches long, but only 1½ line wide throughout)."

Sir Frederick remarks that, in its coriaceous nature and thickness of midrib, this fern is more like "the Cycadaceous *Stangerites* than any other [*Tæniopteris*] I know."† Messrs. Oldham and Morris,‡ in their "Fossil Flora of the Rajmahal Hills," referred the species *Tæniopteris acuminata*, McClelland, *spatulata*, McClelland and *ensis*, Oldham, to the genus *Stangerites* of Bornemann. This genus was created in 1856 to take in those leaves previously known as "*Tæniopteris*, but which resembled the recent *Stangeria*, a plant now known to be Cycadeous, but at first considered to be a fern."‖ Their reason for classing these forms as Cycads seems to be based to a great extent on their pinnate nature and the absence of signs of fructification on their specimens; at the same time they consider also that some of the simple forms as described by Brongniart, may be ferns. The Cycadaceous nature of these plants does not, however, seem to have been accepted, and in a succeeding part of the same work Dr. Feistmantel¶ ranges the

* Prod. Pal. Vict., Dec. ii, p. 15, t. 14, f. 1–2.
† *Op. cit.*, p. 16.
‡ Pal. Indica (Gondwana Flora), 1863, i, Part 1, pp. 32–25, t. 6, t. 23.
§ Ueber organische Reste der Letten Kohlengruppe Thüringens, 1856, p. 59.
‖ Oldham and Morris, *op. cit.*, p. 33.
¶ *Op. cit.*, p. 95.

three species mentioned above under the genus or sub-genus *Angiopteridium*, Schimper, which includes pinnate narrow-leaved Mesozoic Tæniopterids.

Mr. Etheridge, from an examination of a large number of specimens, gives the following specific characters :—" Frond very long, narrow, strap-shaped, elongately lingual, petiolate, straight, slightly curved, or rather flexuous, parallel-sided, or the margins undulating or gently sinuous in places, with an average width of five-sixteenths of an inch. Apex rounded, acute, or emarginate. Petiole strong, striated, and naked. Midrib or costa, thick, striated longitudinally, retaining its size throughout the length of the frond ; veins distant or close, simple or bifurcate, generally at right angles to the midrib, but at times slightly oblique, without curve, dichotomisation taking place near the midrib, or at a variable distance between it and the margin." (Geol. Pal. Q'land, 1892, p. 371.) He also discusses very fully the relationships of the species.

There can, I, think, be no doubt that the *Tæniopteris Daintreei* of McCoy is most closely related to the Indian *Angiopteridium* (*Tæniopteris*) *spathulatum*, McClelland, as has already been remarked by Messrs. Feistmantel,* R. Etheridge, Junr.,† and Shirley.‡ Feistmantel on this subject says : " Of foreigns forms the Australian *Tæniopteris Daintreei*, McCoy, can to a certain extent be compared with this Indian form ; but the veins in the former seem to be still straighter and are thicker than in our species." Commenting on this, Mr. Etheridge remarks : " The latter part of this sentence exactly expresses the difference which exists between the Queensland fossils and McCoy's species as well as between the latter and the Indian plant. It will not, however, surprise me if these species have to be united ; if not, most of the Queensland fronds will have to be referred to *A. spathulatum*, McClelland." Mr. Shirley agrees with these remarks as far as concerns the Queensland leaves, deeming them to be the *A. spathulatum* and distinct from *T. Daintreei* as figured by McCoy.

It must, I think, be admitted by all that the Australian species *Daintreei* belongs to *Angiopteridium*, that numerous leaves varying but little from the type specimens from Victoria are not separable from the Indian *spathulatum*, and, finally, that there is in reality but the slightest evidence in favour of retaining *Daintreei* as a separate species. The variation of thickness of midrib and the slightly straighter direction of the veins are not sufficiently convincing to merit specific distinction, and could easily be due to difference of local conditions. Variations as great or greater than these can be seen in any series of Australian specimens, and after an examination of a large number of

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* Pal. Indica (Gondwana Flora), 1879, i, pt. 4, p. 207.
† Geol. and Pal. Q'land, 1892, p. 373.
‡ Add. Foss. Flor. Q'land, 1897, p. 27.

specimens from the Jurassic beds of the Talbragar River and comparison with Victorian and Queensland specimens, we are, I consider, compelled to admit that the Eastern Autralian *Tæniopteris*, hitherto known generally as *Daintreei*, McCoy, is nothing but the variable Australian representative of the Indian *Angiopteridium spathulatum*, McClelland.

The synonymy of its Indian occurrences is :—

Tæniopteris spathulata, McClelland. Report Geol. Survey India, 1848–49 [1850].
Stangerites spathulata, Oldham and Morris. Pal. Indica, Gondwana Flora, i, 1863, p. 34, t. 6, f. 1–7.
Angiopteridium spathulatum, Schimper. Traité Pal. Vég., 1869, i, p. 605.
Angiopteridium McClellandi, Feistmantel. Records Geol. Survey India, 1876, Flora, ix, pt. 2, p. 36.
Angiopteridium spathulatum, Feistmantel. Pal. Indica, Gondwana Flora, i, 1877, p. 97.
Angiopteridium spathulatum, Feistmantel. Pal. Indica, Gondwana Flora, 1877, 1, pt. 3, p. 172, t. 1, f. 6*b*, 7*b*.
Angiopteridium spathulatum, Feistmantel. Pal. Indica, Gondwana Flora, 1879, i, pt. 4, p. 206, t. 1, f. 8–13, 17, 18 ; ti 2, f. 3, 5, 6 ; t. 15, f. 11.
Tæniopteris spatulata, McClell., Oldham. Man. Geol., India, 2nd ed., 1893, pl. to face p. 176, top right-hand figure.

In Australia, the species has been found at numerous localities in Victoria, New South Wales, and Queensland.

Tæniopteris (Angiopteridium) Carruthersi, *Ten.-Woods.*

T. Daintreei, Carruthers. Quart. Journ. Geol. Soc., 1872, xxviii, p. 355, t. 27, f. 6.
T. Daintreei, Feistmantel. Palæontographica, 1878, Suppl. Bd., iii, Lief. 3, Heft. 3, t. 14, f. 4 (2 and 3 exl.)
T. Carruthersi, Ten.-Woods. Procs. Linn. Soc. N. S. Wales, 1883, viii, pl. 1, p. 117.
T. Carruthersi, Johnston. Procs. R. Soc. Tas. for 1885 [1886], p. 375.
T. Carruthersi, Feistmantel. Sitz. K. B. Akad. Wissens. Math. Naturw. Cl., 1888, p. 630.
T. Carruthersi, Feistmantel. Abhandl, K. B. Gesell. Wissens. Math. Naturw. Cl., 1890, Folge vii, Bd. iii, p. 65, t. 2, f. 6–10.
T. Carruthersi, Feistmantel. Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, p. 115, t. 28, f. 7.
T. Carruthersi, Feistmantel. Uhlonosne Utvary v. Tasmanii, 1890, p. 98, t. 8, f. 14.

T. Carruthersi, Etheridge, R., Jun. Geol. and Pal., Q'land, 1892, p. 374.

Sp. Char.—" Frond simple (?), broad linear, costa somewhat thick, veins leaving it at an acute angle, then passing out at right angles to the margin, once or twice dichotomously divided."—Ten.-Woods.

Mr. Etheridge remarks that *Carruthersi* is a larger plant than the Australian variety of *A. spathulatum—Daintreei.* "The general form is different. The veins, instead of leaving the midrib direct at right angles, as in the case of the species named, pass from it at first obliquely and then assume a similar course to the former." This species was first described as *T. Daintreei* by Carruthers, but the difference between the two forms was pointed out by McCoy.*

This species has been found in Queensland, New South Wales, Tasmania, and South Africa.

Tæniopteris (Angiopteridium), Etheridgei, *Shirley.*

Add. Foss. Flor. Q'land, 1897, p. 27, t. 9, f. 1.

Sp. Char.—" Frond four to six inches; oblong-lanceolate, narrowing towards the base; apex?; midrib less stout than in other Queensland species, considering the width of the frond; veins fine and very numerous, varying considerably in the angle which they make with the mid-vein, but usually arising at an oblique angle, then meeting the margin at right angles; furcation of veins may be sparing or moderately frequent, the fork is generally near the midrib."—*Shirley.*

Mr. Shirley remarks that this is probably the species figured by Etheridge as *Tæniopteris*, sp. ind.†; but a comparison of the figures hardly bears this out, Etheridge's figures differing from Shirley's in the less acute angle at which the veins spring from the midrib, more elongate leaf, much more prominent midrib, and more particularly in the fact that in the Mt. Esk specimen the furcation of the veins is very marked and persistent, whilst in *T. Etheridgei*, Shirley, this character only obtains very rarely, as shown by the Author's figure. In view of these facts, I must consider Mr. Etheridge's specimen to belong to another species.‡

Tæniopteris (Angiopteridium) Tenison Woodsi, *Eth. fil.*

A. ensis, Ten. Woods [*non* Oldham and Morris], Procs. Linn. Soc. N. S. Wales, 1883, viii, p. 119.

A. ensis, Feistmantel, Sitz. K. B. Gesell. Wissens. Math. Naturw. Cl., 1888, p. 631.

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* Geol. Survey Vict., 1875, Dec. 2, p. 16.
† Geol. Pal. Q'land., 1892, p. 374, t. 16, f. 4.
‡ *Vide* p.

A. ensis, Feistmantel, Mem. Geol. Survey, N. S. Wales, Pal. 3, 1890, p. 116.

A. Tenison Woodsi, Etheridge, R. Junr., Geol. and Pal. Q'land, 1892, p. 375.

A. Tenison Woodsi, Shirley, Add. Foss. Flor. Q'land, 1897, p. 29, t. 9, f. 2.

Sp. Char.—"The fronds are long and narrow, nearly three inches, and that without being perfect, ribbon-like, or linear lingual, hardly tapering, and parallel-sided. The midrib is wide and flattened. The veins are very distinct, wide apart, very oblique to the midrib, and very little curved, being almost straight. They bifurcate at about one-third from the midrib. The veins do not fork particularly near the margin, and the latter is not in any way serrated; the former, measured along the margin, are about one millimetre apart."—*Etheridge.*

Mr. Etheridge remarks also that "the outline of the frond is much more that of *Angiopteridium spathulatum* [than *A. ensis*], but the venation is wholly different. From Rosewood, near Ipswich.

Tæniopteris tasmanica, *Johnston.*

Procs. R. Soc. Tas. for 1885 [1886], p. 375.

Feistmantel, Sitz. K. B. Gesell. Wissens. Math. Naturw. Cl., 1888, p. 631.

Johnston, Geol. Tas., 1888, t. 24, f. 3.

Feistmantel, Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, p. 115.

[Feistmantel classes this as a synonym of *T. Carruthersi*, Ten. Woods. Uhlonosne Utvary v. Tasmanii, 1890, pp. 98, 99, t. 8, f. 14.]

"Frond simple, broadly strap-shaped, not obovate; midrib moderately strong; veins well defined, exceedingly close and numerous, parallel, emerging from midrib at an acute angle, and immediately bending and reaching margin at a slight angle upwards. About one nerve in ten simply furcate near middle of wing; about twenty-four nerves in the space of half an inch. Length unknown. Breadth, about forty-six millimetres. Common in the shales at foot of Spring Hill."—*Johnston.*

This fern is said to approach *Macrotæniopteris wianamattæ*, Feistmantel, differing from it in closer neuration and broad strap-shaped form. *T. densinervis*, Feistmantel, differs from it in having more delicate furcate venation.

Tæniopteris (Oleandridium?) fluctuans, *Eth. fil.*

Trans. R. Soc. S. Austr., 1895, xix, pt. 2, p. 139, t. 5, f. 1–3.

Sp. Char.—"Frond simple (so far as known), elongately lanceolate, thick, coriaceous, crumpled, lateral margins sinuous; midrib thick, moderately wide, and possibly longitudinally striated; secondary veins fine, straight, two in the space of one and a half

mm., passing from the midrib at a right angle, sparsely furcate, and when so generally on immediately leaving the midrib, very rarely in the middle of the wing."—*Etheridge.*

This species has so far been found at Leigh's Creek, S.A., only; in size it equals the largest examples of *Carruthersi*, Ten. Woods. It most probably comes under the section *Angiopteridium.*

Tæniopteris, Sp.

Messrs. E. F. Pittman and T. W. E. David collected from a band of ferruginous shale, of Hawkesbury age, at Mount Cockabutta, near Talbragar, portions of a long strap-shaped leaf, in contour very similar to Australian species of *Angiopteridium*, but characterised by a well-marked "goffering" of the leaf, extending from the margin almost to the midrib. No trace of venation is preserved.*

OLEANDRIDIUM.

Oleandridium lentriculiforme, *Eth. fil.*

Records Geol. Survey N.S. Wales, 1894, iv, pt. 2, p. 49, t. 8, f. 1–3; Shirley, Adv. Foss. Fl. Q'land, 1897, p. 28, t. 7., f. 3.

Sp. Char.—"Leaves simple, elongately lanceolate, or boat-shaped, broad in the centre, attenuating both towards the apex and base, petiolate, and apparently more or less coriaceous; apex obtuse to a variable degree, but never acute; petiole long and strong; margins entire, and not waved, gently curved from base to apex; midrib broad and strong near the base, rapidly decreasing upwards to a fine vein; secondary veins rather variable in number in a given space, but generally about three in the space of one millimetre, issuing from the midrib at an oblique angle, but without any change in the direction of their course; seldom dichotomous, but, when so, once only, and then near the midribs." —*Etheridge.*

Mr. Etheridge is of opinion that the nearest ally to this species is *O. stenoneuron*, Schenk.† The New South Wales specimens come from Gosford, in intercalated shales in the Hawkesbury Sandstone, and also from a bed of shale at Freshwater near Manly. Mr. Shirley has recorded it from the Ipswich Beds at Denmark Hill, Ipswich, Queensland.

OLEANDRIDIUM.

(Tæniopteris) Morrisiana, *Johnston.*

Procs. R. Soc. Tas. for 1885 [1886], p. 375.

Feistmantel, Sitz. K. B. Gesell. Wissens. Math. Naturw. Cl., 1888, p. 631.

Feistmantel, Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, p. 115.

* Note on the Stratigraphy of the Fish-bearing Beds of the Talbragar River. Geol. Survey N.S. Wales, 1895, Pal. 9, p. x.

† Foss. Flora Grenschichten, 1868, Atlas, t. 25, f. 3, 4.

"Frond simple, narrowly strap-shaped; costa fine; veins numerous, parallel, one in six simply furcate, emerging and radiating outwards at a moderately acute angle to margin. Length, unknown; breadth about sixteen millimetres; nerves fully one millimetre apart."—*Johnston.*

This species occurs near Longford, in Tasmania. Mr. Johnston considers it to be more closely allied to *Oleandridium vittatum*, Brongniart, than *Tæniopteris* (*Angiopteridium*) *Daintreei-Spathulatum*, McClelland. Judging from his remarks it is very close to *Angiopteridium Carruthersi*, Tenison Woods.

As far as I am aware this species has not been figured.

Tæniopteris (Oleandridium) *sp. ind.*

Etheridge, R., Junr., Trans. R. Soc. S. Austr., 1895, xix, pt. 2, p. 140, t. 41.

Sp. Char.—"Frond linear spathulate, four to five inches long and five-eighths of an inch wide, probably petiolate; margins entire, not fluctuating; surface plain, not crumpled. Midrib very strong, one-sixteenth of an inch wide; secondary veins briefly issuing from the midrib at an acute angle, the diverging at a much more obtuse one, and proceeding to the margins more or less horizontally, one in the space of half a millimetre, and apparently all simple."—*Etheridge.*

Mr. Etheridge points out that in some respects this fern is like *Angiopteridium McClellandi*, Oldham and Morris, especially the figures of the specimens from Tonkin figured by Zeiller,* which differ to a considerable extent from the Indian specimens.

He also considers that it agrees very closely with the simple margined varieties of *Oleandridium tenuinerve*, Brauns.

From the Leigh's Creek Coal-field, South Australia.

MACROTÆNIOPTERIS.

Macrotæniopteris Wianamattæ, *Feistm.*

Palæontographica, 1878, Suppl. Bd. iii, Lief. 3, Heft. 1, p. 107, t. 13, f. 2.

Wilkinson (C. S.), Ann. Rept. Dept. Mines N.S. Wales for 1879 [1880], p. 214, t. v.

Tenison-Woods, Procs. Linn. Soc. N.S. Wales, 1883, viii, p. 118.

Feistmantel, Sitz. K. B. Gesell. Wissens. Math. Ntaurw. Cl., 1888, p. 631.

Feistmantel, Mem. Geol. Survey N.S. Wales, Pal. 3, 1890, p. 116, t. 27, f. 1, 2.

Etheridge, R., Jun., Geol. and Pal. Q'land, 1892, p. 376.

M. Woodsi, Eth. fil., Geol. and Pal. Q'land, 1892, p. 377.

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* Annales des Mines, 1882, t. 10, f. 5.

Etheridge, R., Jun., in Brown (H.Y.L). Rept. Coal-bearing areas neighbourhood of Leigh's Ck., p. 10, p. l., f. 3. (Fol. Adelaide, 1891. By authority.)

Feistmantel, Pal. Indica, Gondwana Flora, iii, ser. xii, 1881, p. 89.

Sp. Char.—"Frond elongately obovate, simple, base attenuate, apex (?); rachis thick, grooved or striated; veins emerging at an angle of twenty to twenty-five degrees, close, near the rachis 0·6 to 0·8 mm. apart, slender, dichotomous towards the margin."—*Feistmantel.*

In Dr. Feistmantel's memoir this species is recorded from the Gib Tunnel, near Bowral, in the Wianamatta shales. Tenison-Woods records it from the Wianamatta of Kenny's Hill, and also from Mount Victoria.* The same author, in his "Memoir on the Fossil Flora of the Coal Deposits of Australia," quoted above, says he has "some similar specimens from near Ipswich, but the dichotomy of the veins is near the rachis, and it may be a distinct species." The specimen figured by Mr. C. S. Wilkinson† is also from Gib Tunnel, and though imperfect tends to show that the form of the apex was ovate. It also has been found at Camperdown. Mr. Wilkinson mentions it as occurring at Parramatta and Nattai, also in the Wianamatta.‡ A *Macrotæniopteris* also occurs in the Narrabeen Beds, but it is not yet certain to which species it belongs.

In Queensland it occurs at Ipswich, and Mr. Etheridge, who records it in the "Geology and Palæontology of Queensland,"§ is of opinion that remarks as to the possibilities of it (the Queensland species) being a new species are unfounded. It has also been found in the Leigh's Creek Coal-field, South Australia.||

Macrotæniopteris crassinervis, *Feistmantel.*

Pal. Indica (Gondwana Flora), 1877, Ser. 2, I, pt. 2, p. 102, t. 38, f. 1-3.

Etheridge, R. junr., Geol. and Pal. Q'land, 1892, p. 376, t. 16, f. 5.

Sp. Char.—"Frond very large, single, strong, thick, and coriaceous, broad, elongately obovate; margins plain; apex obtusely rounded, not re-entrant; midrib distinct, but not wide for the size of the frond, vertically ridged; veins, except near the apex, diverging at a right angle, or nearly so, very strong; distant from one to one and a half millimetres apart, very regular and direct in their course, simple or forked; dichotomisation at irregular intervals, but always dividing close to the midrib."—*Etheridge.*

* Journ. R. Soc. N. S. Wales, for 1883 [1884], xvii, p. 82.
† Ann. Rept. Dept. Mines N. S. Wales, for 1879 [1880], t. v.
‡ Min. Prod., 1887, 2nd Ed., p. 76.
§ P. 376.
|| Etheridge, *op. cit. supra*, p. 10.

This species is classed with the Indian on account of the coarse neuration "and the uniform manner in which the veins divide close to the midrib." Mr. Etheridge states that, as preserved, the leaf is fifteen inches long and probably five inches wide. He compares it to *M. lata*, Oldham and Morris, but the frond is more delicate and the veins finer and closer.

The Australian specimen was collected at Wycarbah, near Rockhampton.

Macrotæniopteris Woodsi, *Eth. fil.*

Etheridge, R., jun., Geol. & Pal. Q'land, 1892, p. 377.

Near *M. Wianamattæ*, Feist. "On emerging from the midrib, or costa, the veins are strong and about one thirty-second of an inch apart, but after bifurcation they become exceedingly fine and close together. The subdivision takes place near the rachis, and in this it differs from the species abovenamed, in which bifurcation is much nearer the margin."

I venture to think that this species, which is only tentatively considered as new by Mr. Etheridge, is nothing but a variety of *Wianamattæ*. This appears to be borne out by Mr. Etheridge's remarks on *M. Wianamattæ* on the preceding page, when, in speaking of Tenison Woods' remarks that what appears to be a similar specimen might be another species, he says, "This separation will hardly, therefore, hold good."

This specimen is from the Tivoli Coal-mine, Ipswich, Queensland.

Genus—Phyllopteris, *Brongniart*, 1849.

(*Fide* Saporta, Pal. France, Pl. Jurassiques, 1873, i, p. 448.)

Phyllopteris Feistmanteli, *Eth. fil.*

Geol. and Pal. Q'land, 1892, p. 375. Etheridge in Brown (H. Y. L.). Further Geol. Exam. Leigh's Creek and Hergott Springs, p. 3, t. 1, f. 1, 2. (Fol., Adelaide, 1892. By Authority).

Sp. Char.—"Frond, or leaflet, oval, or broadly lanceolate, slightly petiolate; midribs very distinct, evanescing towards the apex of the leaflet, but tapering very slowly; veins springing outwards from the midribs at a very acute angle, then gracefully curving outwards to the margin, fine, once or twice furcate."—*Etheridge.*

This species has been collected from Stewart's Creek, Stanwell, near Rockhampton, and the Styx River Coal-shaft, Styx River, Broad Sound, Queensland, from rocks of the Ipswich formation. In South Australia it occurs in the Leigh's Creek Coal-field of the same age.

Some imperfect leaves of *Phyllopteris* occur at Cockabutta Mountain, near Talbragar, in shale of Hawkesbury age. (Mem. Geol. Survey N. S. Wales, Pal. 9, 1895, p. x.)

Distribution of the Tæniopteridæ in Australia.

Species.	New South Wales.					Queensland.				South Australia.	Victoria.	Tasmania.
	Hawkesbury series.	Wianamatta.	Talbragar.	Clarence series.	Narrabeen.	Ipswich coal-measures.	Burrum coal-measures.	Stewart's Creek beds.	Rosewood & Wycarpah beds.	Leigh's Creek coal-measures.	Lower Mesozoic coal-measures.	
TÆNIOPTERIS.												
Angiopteridium spathulatum var. Daintreei.	...	...	×	×	...	×	×	×	...	...	×	...
,, Carruthersi	...	...	...	...	?	×	...	×	×	...	...	×
,, Etheridgei.........	...	...	...	...	...	×	...	...	...	...	...	...
,, Tenison Woodsi..	...	...	...	...	...	×	...	...	...	...	...	...
,, Tasmanica...... ,, =Carruthersi	...	...	...	...	...	...	...	...	...	...	...	×
,, fluctuans	...	...	...	...	...	...	...	...	...	×	...	...
,, sp. ind.	...	...	×	...	...	...	...	...	...	...	...	...
OLEANDRIDIUM.												
Oleandridium lentriculiforme	×	...	...	...	...	×	...	...	...	...	...	...
,, Morrisiana	...	...	...	...	...	...	...	...	...	...	...	×
,, sp. ind.	...	...	...	...	...	...	...	...	...	...	×	...
MACROTÆNIOPTERIS.												
Macrotæniopteris Wianamattæ ...	...	×	...	...	...	...	...	...	...	...	...	...
,, crassinervis	...	...	...	...	...	×	...	...	×	...	×	...
,, (Woodsi = Wianamattæ).	...	...	...	...	...	×	...	...	...	...	...	...
PHYLLOPTERIS.												
Phyllopteris Feistmanteli	...	...	...	...	...	×	...	×	...	×	...	...
,, Danæopsis, sp.	...	...	×	...	...	...	...	...	...	...	...	...
,, Danæopsis (?)	×	...	...	...	×	...	...	...	...	...	...	...

No. 17.—ORE DEPOSITS OF THE SILVER SPUR.

By H. G. Stokes.

(*Read Wednesday, January* 12, 1898.)

No. 18.—AN EXAMINATION OF THE TASMANIAN GRAPTOLITE RECORD.

By T. S. Hall, M.A.

(*Read Wednesday, January* 12, 1898.)

Having been led to investigate the Tasmanian Graptolite record, I thought that it might be as well to bring forward the information which I had gathered, especially as some of it is derived at first hand from the gentleman who announced the discovery of these organisms in the Tasmanian rocks.

In his "Report on the Mineral Resources and on the Permanency of the Lisle Gold-field," Mr. Thureau*, in dealing with the "Geological Features," says: "These comprise regularly bedded slates and sandstones from blue to grey in colour; in the former incomplete petrifactions (*Diplograpsus nodosus*) were observed, resembling to some extent the Victorian series of Graptolitidæ." Mr. R. M. Johnston, in a letter replying to my request for further information, tells me that this is the only record of which he is aware, and that he has never seen any specimens of Tasmanian graptolites. Mr. A. Montgomery, formerly Government Geologist of that colony, has also kindly answered me to the same effect, and states that he was unable to find any graptolites in the neighbourhood of the alleged find. Taking advantage of the presence of Mr. Thureau in Melbourne, I closely cross questioned him on the subject, and he good-naturedly gave me all the information he could. The specimen has disappeared, and Mr. Thureau has no notes dealing with it, so that that line of inquiry is blocked. Mr. Thureau, however, says he recollects the specimen perfectly. There was but one, and he is quite certain it was a *Diplograptus*, and nearly 3 inches in length. This he carried to Strahan, and there identified it from memory, no books of reference being available; nor did he at any later time compare it with the figure and description, and shortly after lost it. It is apparent that a specific determination of this kind is valueless. There can, I think, be little doubt that the specimen was a graptolite, and, moreover, one of the *Diplograptidæ*; for it must be remembered that Mr. Thureau was familiar with these fossils, having lived for some time in Bendigo, where he had collected them and sent specimens to Sir Frederick McCoy, one being a new generic type. As regards the species, however, to which Mr. Thureau referred, his specimen,

* Tasmanian House of Assembly Journals, vol. xliii, 1882. Paper No. 146.

a more unfortunate one could hardly have been chosen. *Diprion nodosus,* as originally described by Harkness,* was founded on an imperfect specimen, and shows hydrothecæ of a form unknown outside the Monograptidæ. Carruthers, without any remark, quotes it as a synonym of *Graptolites becki*, Barr,† itself a synoym of *Monograptus lobiferus*, McCoy, and the reference appears to be universally accepted. Harkness' specimen came from (Upper) Silurian beds, so that we have the peculiar result, that chiefly on the supposed identification of an (Upper) Silurian graptolite, the beds at Lisle are referred to Ordovician. If, however, we disregard the specific identification and accept Mr. Thureau's statement, that the specimen found by him was a *Diplograptus*, then the age may be anything from Lower Arenig to Tarannon. Mr. R. M. Johnston, in his great work on the Geology of Tasmania, refers the Lisle beds to the lower part of the Lower Silurian (Ordovician), placing them below the Gordon River beds, which do not come into contact with them, and which on other evidence he regards as of Caradoc age. Now it so happens that a series of Lower Ordovician graptolites had previously been recorded from Victoria, and a perhaps unconscious reference to Victorian beds would appear to have unduly influenced Mr. Johnston in forming his conclusions as to the age of the Lisle slates. The Victorian graptolites taken cognisance of by Lapworth in his series of papers on the geological distribution of these forms, are regarded by him as ranging from Lower Arenig to Llandeilo-Bala (Glenkiln), and a couple of Silurian species had also been recorded by Sir Frederick McCoy, a *Monograptus* and a *Gladiolites* (*Retiolites*). This was the state of our knowledge when Mr. Johnston wrote, so that even then were a Victorian comparison desired there was a wide field to choose from. Since then the field has been extended, for we can now range from Tremadoc to a yet undecided horizon in the Silurian series, quite possibly into the Ludlow—that is using the terms in a loose way, for it is by no means certain that the sequence of our forms will be found in exact accord with that observed in the Northern Hemisphere, or that exact correlation with beds there will be possible.

In conclusion, it may be, it would seem, only reasonable to believe that a *Diplograptus* was found in Tasmania by Mr. Thureau, and, as the range of the genus was so great, that no definite conclusions can be drawn from its occurrence.

No. 19.—ON THE GEOLOGY OF THE COW FLAT DISTRICT, NEAR BATHURST, N.S. WALES.

By A. C. Andrews, B.A.

(*Read Wednesday, January* 12, 1898.)

* Q.J.G.S. vii (1850), p. 58, pl. 1, fig. 10. † Geol. Mag. v (1868), p. 64.

SECTION D.

BIOLOGY.

PRESIDENTIAL ADDRESS.

By C. J. MARTIN, D.Sc., M.B., Acting Professor of Physiology in the University of Melbourne.

(*Delivered Friday, January* 7, 1898.)

THE HISTORY OF THE RELATIONS BETWEEN MORPHOLOGY AND PHYSIOLOGY DURING THE LAST FIFTY YEARS.

THE reason I occupy my present position is, as you are aware, owing to the unfortunate death of our President-elect, Professor Jeffrey Parker, D.Sc., F.R.S. By his death science has lost a first-class worker, and one who has been most prominent in forwarding the reputation of Australian Biologists.

Soon after graduating at the University of London, Thomas Jeffrey Parker was demonstrator to the late Professor Huxley from 1872 until 1880, when he was appointed to the Chair of Biology in the University of Otago. During these eight years Parker did fine work in co-operation with his chief, Professor Huxley, in establishing the teaching of Biology upon rational methods. The teaching museum on the type system, and other arrangements for practical teaching, were, to a large extent, the result of his energies. The duties of the Chair of Biology at Otago were fulfilled by Professor Parker until within a few months of his death.

Dr. Parker's work, as a Biologist, was of the very highest order, and did much to enhance the reputation of the University in which he taught for so many years. He was a lucid and fascinating teacher, the charm of whose teaching was in a large degree due to the possession of keen humour, and an accurate and artistic sense of proportion combined with perfect good taste. He also possessed the capacity of skilful delineation upon the blackboard, which is so invaluable to a teacher of Biology. Indeed, his talent in this direction was such that it always seemed a pity that these drawings should only have such an ephemeral existence.

Dr. Parker has been an important contributor to the literature of Biology, and especially to that part of the subject dealing with the indigenous fauna of New Zealand. His memoir on the "Anatomy and Development of Apteryx," published in the Transactions of the Royal Society in 1891, is a master-piece, and must remain the classical work on the subject long after Apteryx is extinct.

Amongst his most important published contributions have been two excellent text-books—"Zootomy," published in 1884, and "Lessons in Elementary Biology," which appeared in 1893. The latter of these books is extensively used wherever Biology is best taught in England. They have both been translated into German, and successfully hold their own in that land of scientific treatises.

Of late years Dr. Parker had been engaged, in conjunction with his friend, Professor Haswell, of the University of Sydney, in writing a more advanced text-book of Zoology, the last proof-sheets of which passed through his hands shortly before he died. Those who have had the privilege of seeing the pages of this work as it was passing through the press are of opinion that it is to be the leading advanced text-book of Zoology in the English language, and that English zoologists will no longer have all their text-books translations from German authors. The work is abundantly and excellently illustrated; and the plan is novel. In each section there is first given a general semi-popular statement with regard to the extent and characteristics of the phylum dealt with ; then a detailed description of an example. This is followed by a brief statement of the distinctive characters of the phylum and of its main divisions, with an account of the position of the example in the scheme of classification. Finally, there comes the general organisation of the phylum, treated comparatively.

Much of Dr. Parker's time was occupied in the development of the Museum of Comparative Anatomy. In this kind of work he was particularly expert, and his glycerine-gelatin method for preserving cartilaginous specimens has been universally adopted.

When one considers that in the comparative isolation of Dunedin, in addition to the organisation and museum work connected with his chair, Dr. Parker has published monographs monumental for accuracy of detail, and two text-books universally recognised as the best for the purpose they were intended, we must look upon him as a splendid example to try and follow with the intention of shifting the meridian of Biological Science some little to the eastward.

When my friend Professor Haswell wrote to me a few weeks ago asking whether I were willing to accept the honour of the presidency of section D, he reassuringly told me that under the circumstances only a very little address would be expected.

Notwithstanding this assurance I felt no small difficulty in deciding upon a topic suitable to bring to your notice. I could

not, for instance, give you a running survey of "the progress of zoology during the Victorian era," as was projected by the late Professor Parker. My position as president of a biological section is somewhat peculiar, for while I may perhaps claim to be a biologist in the more generous meaning of the term, my knowledge of the details of animal and vegetable morphology is unfortunately of a scanty description, so that at the present time I regret, as I often have regretted, the divorce which happened many years ago between those who studied structure and those who studied function.

The consideration of my disabilities has, however, furnished me with an inspiration regarding the subject for an address, and I don't think under the conditions I could do better than endeavour very briefly to place before you (1) the circumstances which led to this divorce of the studies of morphology and physiology, (2) the kind of work which morphologists and physiologists have been doing since the separation, together with the indications of a *rapprochement* of these two subjects at the present time.

At the outset I may say that my remarks apply almost entirely to animal biology. Students of vegetable life have been more fortunate than we, in that this separation of the study of structure and function has occurred to a much smaller extent.

Until fifty or sixty years ago the study of structure and function went hand in hand. The old anatomists as Hunter, V. Humboldt, Bichat, Johannes Müller, were also physiologists. Not only were these two subjects inseparably associated in the interest of the investigators, but the teaching of both divisions of biology was until an even later date usually entrusted to the same man.

How, then, came they to be so widely divorced that many a morphologist regards an elementary acquaintance with the principles of physiology as hardly within his domain, and vice versa, many physiologists, distinguished in some particular direction, have been wont to consider that the business of the morphologist has no interest for them?

I have no hesitation in saying that differentiation has been carried to a pernicious extent in our science. Biology should still represent the study of living things. The morphologist has sometimes almost appeared to lose sight of this, by working continuously at structure as evidenced by spirit-hardened specimens together with microscopical sections of material, which has been stewed in paraffin and stained by various methods born of the ingenuity of that product of extreme differentiation, the microtomist. Physiologists have also often, I fear, been equally blinded to the fuller aims of their science in their endeavours to push present knowledge of mechanism, whether physical or chemical, as a complete explanation of some physiological process, forgetful, for the time-being, that there were two or three layers of living

cells, in which, or through which, the mechanical or chemical process had to operate; and that these same insignificant living units might have something to say in the transaction.

Some separation was, to a certain extent, unavoidable. As the science of biology grew so rapidly, no one individual was capable of appreciating the details of all branches of the science, much less of being an investigator in many branches. Together with everybody else, students of biology had naturally to submit to differentiation of function. But I do not think that such a wide separation, such that—metaphorically—morphologists and physiologists have hardly been upon speaking terms for many years, was necessitated by the exigencies of accumulated knowledge.

THE CAUSES OF THE SEPARATION OF THE STUDIES OF STRUCTURE AND FUNCTION.

I think it must be admitted that this separation occurred, firstly, owing to physiologists approaching the studies of the activities of living organisms from a point of view with which the anatomists were totally unsympathetic; and secondly, in a minor degree, owing to the rapid development of the study of physiology along chemical and physical lines, which necessitated on the part of physiological investigators a previous considerable acquaintance with, and command of, physical methods of research.

It was physiology that changed, not anatomy, or rather perhaps developed rapidly in the direction I have mentioned at this time, 1845–50. Comparative anatomy continued, for the time-being, very steadily along the lines on which St. Hilaire and Müller had worked, the leading principle of which was homology.

In reviewing the history of biological inquiry of the earlier part of this century, the most striking feature was the discovery, by Schwann, that the bodies of animals, just as had been shown to be the case with plants, were composed of cells.

Schwann published his epoch-making results in his "Microscopical Researches" in 1839. The "Microscopical Researches" contains, in addition to his work regarding cell structure, a deliberate attempt to explain cell formation and cell activities, as due to the molecular properties of the cell. According to this theory all physiological phenomena are either grossly mechanical, or to be explained by the chemical reaction of molecules. He was fully aware of the impossibility of presenting any sort of clear conception of the essential mechanism of vital phenomena, but insists most strongly that the consideration of physiological activities from the point of view of chemistry and physics is likely to be more productive than their arrangement in a teleological category, as adopted for a definite purpose.

That this is a sufficient statement of Schwann's point of view will be seen from the following quotation, p. 187:—"The other view (that is, the mechanical espoused by Schwann) is, that the fundamental powers of organised bodies agree essentially with those of inorganic nature, that they work altogether blindly according to laws of necessity and irrespective of any purpose, that they are powers which are as much established with the existence of matter as the physical powers are. It might be assumed that the powers which form organised bodies do not appear at all in inorganic nature, because this or that particular combination of molecules, by which the powers are elicited, does not occur in inorganic nature, and yet they might not be essentially distinct from physical and chemical powers." Schwann points out that teleological views of nature used to be common in physics, such as the "horror vacui," but have long since been discarded, and he is of opinion that there is no necessity for admitting the teleological view in the case of organised bodies.

I have dealt thus with Schwann's views, because I wish to show that the regarding of the phenomena of biology from the point of view of mechanism was most definitely advanced by him. Professor Burdon Sanderson in his address to the British Association in 1889 makes no mention of Schwann, but after briefly reviewing the later work of Mayer upon the relation between the work done and heat given out by muscle and the chemical changes occurring in the muscle, published in 1845, and the subsequent rapidly following discoveries of Ludwig upon the mechanics of the circulation, du Bois Reymond on the electrical proportions of nerve and muscle, and Helmholtz upon colour vision, says: "The effect of these discoveries was to produce a complete revolution in the ways of thinking and speaking about the phenomena of life." There is not the slightest doubt that the brilliant discoveries of all these men immensely contributed to change the point of view, because they showed magnificent results obtained by attacking the problems of physiology from this side, whereas Schwann in the "Microscopical Researches" merely advocated it.

We will now turn to the bearing of the views put forward in the "Microscopical Researches" upon the separation of anatomy and physiology which occurred soon after.

Schwann's theoretical conceptions could not possibly meet with sympathy from the anatomists, with whom the ideas of homology and adaptation to function were leading principles. To the student of form and structure, the view that biological activities were regulated "blindly according to laws of necessity, and irrespective of any purpose," appeared just so much nonsense.

It was impossible to regard the variation in form of homologous structures, such as the wing of a bird and the fore-limb of a mammal, irrespective of adaptation to the functions of flying or walking.

On the other hand, physiologists working at the circulation of the blood, the optical properties of the eye, the changes occurring to food under the influence of the digestive juices, the relationship between the chemical changes occurring in muscle and the work and heat given out, were equally confident that the only interpretation of these phenomena was to be found in the laws of necessity regulating the relationships of matter as known to chemistry and physics.

These two ways of viewing biology were, indeed, irreconcilable, and necessitated those who studied function parting company; nor can we wonder that they had little sympathy with each other's point of view.

SKETCH OF THE PROGRESS OF ANATOMY AND PHYSIOLOGY AFTER THEIR SEPARATION UNTIL THE PRESENT TIME.

I shall now attempt to indicate what each of the great divisions of biology has been doing during the last fifty years, and the points to which each has separately arrived, by different methods and along different lines. I shall not attempt to give a complete survey of the work done, but only in the most general way draw your attention to the kind of work each division has been doing. As regards anatomy in particular, my remarks must be taken as a mere impressionist picture, taken from afar and in a dim light, for I am not competent to depict anatomical progress or results in any detail.

After the physiologists had started off with the notion of interpreting vital activities in terms of the simpler laws of chemistry and physics, the anatomists continued to gather in facts concerning the structure of all kinds of animals. They systematised their knowledge by means of the leading principle of homology.

When in 1859 Darwin's "Origin of Species" was published, the morphologists had their time fully occupied for some years, until they had verified a system under which they could classify all their facts, which was complete in itself, and represented the order of the plant and animal world. Observations in the domain of palæontology and embryology henceforth received a greatly increased value. An army of students of comparative embryology soon arose, and the one man who stands out most prominently as a leader in the development in this direction is Balfour.

Broadly speaking, up to within recent years, the morphologists have been busy discovering new facts, and arranging them in their system, until at the present time morphology has come to express the study of the formation and structure of animals and plants in relation to community of descent.

They are industriously constructing a huge genealogical tree of the organised world, and in this work alone there is room for

whole armies of workers for centuries to come, even if it be possible to ever bridge over the gaps which exist owing to the extermination of intermediate types which have left no fossil remains. In the meantime, in the absence of data by means of which reasonably direct descent can be established, we must be careful, lest in our enthusiastic endeavours to present a completed pedigree, we too closely resemble the efforts of the College of Arms, which, I believe, are always satisfactorily perfect.

The doctrine of evolution, as well as supplying anatomists with a system, afforded by its principle of natural selection a new interpretation of the teleological arguments, the validity of which were necessarily so convincing to every morphologist. For, whereas, in the old teleology, adaptation of structure to function was a sufficient explanation of the existence of structural variation, Darwin showed that it is possible to go further than this, and explain how the adaptation exists and continues to exist. He showed that adaptation itself might be the effect of a sum total of causes, or, in other words, to the operation of natural selection.

By showing morphologists that, although they might justly provisionally arrange their facts in a teleological category, adaptation itself is capable of a casual interpretation, Darwin, once for all, disposed of the inconsistency which had arisen between the points of view of students of form and function. Natural selection is explicable without going outside the material laws of the inorganic world, consequently adaptation of structure to function may, after all, "be regulated blindly, according to the laws of necessity"—a view of vital phenomena, which, when put forward by Schwann, in 1839, appeared so impossible to anatomists.

Having accumulated an overwhelming mass of evidence to establish the doctrine of evolution, morphologists have, during the last ten years, been discussing whether the factors, natural selection or sexual selection, put forward by Darwin, are adequate to explain the origin of species, or whether it is necessary to find some further factor.

Whilst the majority of biologists fully agree that natural selection is sufficient to produce an evolutionary advance in type, they feel that this factor alone would only account for a monotypic evolution as long as free intercrossing can take place. The result of free crossing would level down all variations. Cross-breeding and its consequences may be prevented by geographical and climatic isolation just as it is intentionally prevented by artificial selection in breeding, but geographical and climatic isolation cannot, however, explain the existence of distinct species inhabiting the same area.

The fact that most animals and plants of different species are relatively or absolutely infertile one with another, has frequently been advanced by opponents of natural selection in favour of

fixity of species. Natural selection, however, rests upon a sufficiently secure basis and is not really weakened because it does not afford an explanation of the mutual sterility of allied species. This infertility is, however, a most important fact in biology, and I think the explanation was found by Gulick* and Romanes.† These authors advanced evidence to show that as variations occurred they became relatively infertile, first with the parent stock, and, secondly, with some of the variations among themselves.

The causation of this progressive infertility is not explained; but Gulick's observations leave little doubt as to its existence. If the operation of this factor be granted, then as variations became more markedly distinguished one from another, a corresponding degree of infertility might be expected, and this must inevitably lead to a polytypic evolution.

The assurance that structural variation, as seen in all the different groups of animals and plants, is to be interpreted by the principle of community of descent, has once more attracted the attention of morphologists to the problems of growth and heredity, and an all-important question to them at the present time is the mechanism underlying these phenomena. These are essentially physiological problems, and nothing illustrates the complete coincidence in point of view between modern morphology and physiology than the stand-point from which anatomists have attacked these questions.

Morphologists seem to be so assured that these problems are to be explained in terms of mechanism as almost to make a simple physiologist who has hitherto worked at problems more obviously chemical or grossly mechanical, shiver at their temerity; for while the physiologist does not desire to cry a halt at this point, the *known* laws of chemistry and physics seem so hopelessly incapable of furnishing any interpretation of such things.

Darwin, who fully realised this, put forward with diffidence his theory of pangenesis as a merely working hypothesis. The last ten years has seen much controversy anent heridity, and the now well-known theory has been advanced by Weismann to explain it. This theory recalls the old preformation theory of the seventeenth and eighteenth centuries, put forward by Haller and Bonnet, according to which the germ cell contained in miniature the whole structure of the adult which was gradually unfolded. Weismann observed that in Sagitta certain cells of the embryo are early set apart to form the germ cells of the next generation. The germ plasm is thus in direct continuity through successive generations.

According to Weismann and His even the earliest segmentation cells of an embryo possess distinct and specific potentialities.

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* Jour. Linn. Soc. Zool. xix, 337. † *Nineteenth Century*, January, 1887, p. 61.

This view received powerful support from the experiments of Roux. Roux cut a segmenting frog's ovum, consisting of two cells, into halves. Both halves continued to segment and produced hemi-embryos, which lacked one half of the body. That the potentialities of the cells of an embryo are certainly early differentiated must be conceded by all, but this differentiation would appear, from the observations of Hertwig, Pfluger, and Driesch, to occur later in the history of the segmenting ovum than Weismann imagined.

These authors also succeeded in separating single blastomeres of segmenting ova, and found, in opposition to the results of Roux, that they developed into complete, though dwarfed larvæ.

From the results of Hertwig, segmentation in early stages appears quantitative rather than qualitative, and the earliest segmentation cells are, therefore, isodynamic.

The general truth of Weismann's theory must I think, be admitted, but when he postulates from complexity of function, corresponding complexity of mechanical structure, and talks familiarly of ids, idants, determinants, and biophors !—my head swims, and I feel, also, that a too-continuous repetition of these terms occasions a liability to overlook their highly speculative nature. He also appears quite unjustified in choosing the nucleus, or a part only of the nucleus, as the vehicle for his hereditary mechanism. True, most interesting and suggestive behaviour has been observed on the part of the chromatin filaments prior to and during division; but has not one's attention been directed to this part of the whole cell by the accidental circumstance that it stains, or is otherwise easily made visible, whereas we are left mostly in the dark as to what is taking place in the remaining portion ?

Whatever one's opinion of the value of Weismann's theory may be, one must realise the immense value of his work in stirring up controversy and research in this field, and especially for so forcibly pointing out that a great principle in heredity—namely, the transmission of acquired peculiarities—had been tacitly admitted with altogether insufficient credentials. The conception of a germ possessed of such an infinitely complicated architecture as is necessitated by Weismann's theory does not attract me. It is, at the same time, too complex in detail, too simple in principle.

Nevertheless, I fully realise the value of any consistent theory of heredity to provide pegs whereon to hang facts for the time-being in some sort of order, instead of their being littered about the journals of the whole civilised world. It provides biologists with a systematized wardrobe, the arrangement of which is easily acquired. In the mean time, they may continue to gather their facts by observation and experiment, for the purpose of formulating some general laws of heredity.

That work of this kind is being accomplished, I may mention the recent experimental confirmation by Francis Galton of his "Law of Heredity," published in 1889. In this monograph he gives *a priori* reasons for computing that of the total heritage of the child, each of the two parents contributes one-fourth, each of the four grandparents one-sixteenth, and the remaining one-fourth from more remote ancestors.

Galton has examined the pedigree book of the Basset (hound) Club with reference to the appearance of black in these hounds, and finds that the number of hounds in any generation which had black on them agreed with the calculated number according to the above law within an error of 1 per cent. The value of such a law (if it be established) as a contribution to the subject of heredity, and for its immediate practical value to breeders, can hardly be overestimated. This kind of work may quite well proceed, although one may not in the least appreciate the essential mechanism underlying heredity. The discovery of the laws concerning the attraction of matter for matter has proved sufficiently interesting and far-reaching in importance, although at the present time one has no conception of the details of the process.

In tracing the development of physiology as it exists at the present time, the line of descent passes through Johannes Müller. Müller was essentially a comparative anatomist, and comparative physiologist, whose aim was the study of the essential phenomena of life in all its aspects. Müller was a vitalist, that is to say, he regarded the forces operating in living beings as something other, and essentially distinct from those of inorganic nature. He insisted upon the advantage to physiology which accrues by studying it from a comparative point of view, so that on the one hand simplicity of structure, and on the other differentiation of function might be utilized. His researches extended over the whole field of biological enquiry, and his text-book of physiology as a philosophical exposition of the subject at the time has never been surpassed.

The characteristic of this book is its breadth of view. It is essentially a general physiology, the aims of which were to study the phenomena of life in all their aspects. Observations and experiments on every form of living creature here find a place, because Müller was convinced that an essential identity underlay the manifestations of every form of vital activity.

Towards the latter end of his life Müller confined his attention more and more to the study of anatomy, and had little sympathy with the mechanical interpretation of vital phenomena maintained by the younger physiologists, among whom were some of his own pupils.

Rather over fifty years ago the study of physiology received a great impetus, largely owing to five, at that time, young men, Ludwig, Helmholtz, Brücke, and du Bois Reymond in Germany,

and Claude Bernard in France. In 1847 the four first met together in Berlin. Ludwig used often to speak of this, and say, "We four imagined that we should constitute physiology on a chemico-physical basis, and give it equal scientific rank with physics."

Reviewing physiology at the present day, after the lapse of fifty years, although it is certain that the efforts of these men and their pupils—for so many physiologists in Europe and America were directly or indirectly pupils of one of these men—may not have succeeded in placing physiology on the same level with physics as an exact science, yet they have enormously advanced all physiological observations in the direction of accuracy. Their partial success is due to the much greater complexity of the problems to be solved, and the greater difficulty in obtaining exact measurements, and not necessarily to less accuracy in experimental methods.

Incidentally, too, it is reassuring to remember that these men, working at physiological problems, have done yeoman service to physics. Ludwig first introduced the graphic method of recording any movement upon a travelling surface, which is at present in use in every physical laboratory, and indeed universally applied; and Helmholtz published his famous essay on the conservation of energy (Erhaltung der Kraft) whilst still a physiologist.

The determination of these men to systematically attack physiological problems by the methods of chemistry and physics is often spoken of as a revolution. Like other revolutions, however, history shows that it was not such a sudden transition as has been stated. True, the physiology antecedent to this date was rather too much inclined to fall back upon the phrase "vital force," and to accept a teleological reason as the explanation of phenomena concerning living organisms; but there had been physiologists such as Stephen Hales, Poiselle, Majendie, Weber, and Johannes Müller, who certainly tried to measure physiological phenomena in much the same way as was applied in physics, and Liebig, indeed, regarded a considerable portion of physiology as simply a branch of chemistry. The splendid impetus given to physiology about this period appears to me to be due, not to an entirely new way of approaching its problems, but to the vast superiority of the experimental methods employed. In other words, the advance was due, not so much to change of direction, but to superior tactics.

I will now endeavour by two or three examples to represent to you the kind of work physiologists have been doing during the past fifty years.

At the outset, I may say that until comparatively recently the physiological investigation of the last half century has been almost confined to the study of function in the higher animals. Unlike Müller, who experimented upon every kind of animal backboned

or not, the modern school of physiologists have concerned themselves almost exclusively with one or two of the higher mammals and the frog.

As my first example, I will take the subject of respiration. This function may be divided in a higher animal into four stages.

(1.) The mechanical arrangements for the inhalation and exhalation of air.

(2.) The entrance of O_2 from the air into the blood and exit of CO_2 from the blood into the air.

(3.) The way in which O_2 is carried to the tissues and CO_2 away.

(4.) The taking up of O_2 by the cells and the excretion of CO_2.

On regarding these four stages, it will be seen that of all of them the fourth is the essentially respiratory act, an act common to the whole of the animal kingdom, and I may say at once that it is the only one we know little or nothing about.

Of the first three stages, the last fifty years have contributed greatly to our exact understanding. Inhalation and exhalation are accomplished by alteration in the thoracic pressure, and take place according to the laws of ærodynamics.

The orderly sequence of inspiration and expiration is brought about by a nervous mechanism, the precise arrangement of which has been disclosed in considerable detail. Accurate analyses of inspired and expired air have been made which have shown that out of every 100 volumes of air about five volumes of oxygen disappear and about four volumes of CO_2 appear.

It has been shown that the operation of inhalation and exhalation by itself only succeeds in filling or emptying that portion of the respiratory apparatus which is nearest the surface, viz.:—the trachea and large bronchi, and that the interchange of gases between this point and the alveoli takes place according to the laws of diffusion of gases.

The amount of the gases oxygen, nitrogen, and carbonic acid contained in arterial and venous blood have been determined with considerable accuracy, and the fact established that the oxygen lost to the air in the lungs is gained by the blood coming from them, and that the carbonic acid gained by the air whilst in the lungs is proportional to that lost by the venous blood in this situation.

Further than this, the partial pressure of the O_2 & CO_2, in the alveolar air has been determined by more or less indirect methods, and also the partial pressures of those same gases both in venous and arterial blood. The results show that the exchange of gas

between the blood plasma and the alveolar air is regulated to some extent according to the law of partial pressures.*

We know that oxygen is conveyed by the blood all round the body, and that the amount of oxygen which a given volume of blood can so transport is immensely increased by the presence of the proteid hæmoglobin in the corpuscles. The chemical properties of hæmoglobin and its relation to oxygen, have been accurately ascertained. One knows precisely the conditions under which the two form a stable compound, and those under which they dissociate, and how, on account of the peculiarity of these conditions, it is so admirably adapted to perform its role in the economy. How it becomes a saturated compound where the tension of O_2 is relatively high (the plasma in the lungs), and breaks down where this tension is low (the capillaries). By this dissociation oxygen is once more set free in the plasma, and diffuses thence through the capillary wall into the fluid which surrounds the various cells. From this situation it disappears, and is absorbed by the cells, and firmly locked up within them in some form of chemical combination. Beyond this point we cannot trace it, but the next thing known is that it reappears as CO_2, having undergone this transformation whilst within the cell.

The history of CO_2 during its passage from the tissues to the alveolar air has also been investigated, and we are in possession of facts which show that this also takes place according to more or less simple laws of chemistry and physics. Transit is accomplished according to the laws of partial pressures, assisted by chemical combinations for the time being with the carbonates and phosphates of the blood plasma which operate in a manner somewhat analagous to that of hæmoglobin with oxygen.

As a second example of the kind of knowledge obtained by the methods of recent physiology, I will take vision.

Concerning the mechanical principles of the organ of vision, the knowledge obtained during the last ten years—owing largely to the energies of Helmholtz and Donders—is so comprehensive and complete that it gives one the impression that little more could be added to it. The minute anatomy of the eye, the optical properties of its various media, and its various defects as an optical instrument, have been closely investigated. The exact mechanism by means of which accommodation is effected, peripheral rays excluded when increased refraction from the periphery of the

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* The discovery by Bohr, and later confirmation by Haldane and Lorain Smith, that the tension of O_2 is frequently higher in arterial blood than in alveolar air, whereas the tension of CO_2 is often lower in the arterial blood than in such air, cannot be explained by diffusion across a membrane, with which one is so far acquainted in physical experiments. If, however, one assumes a physiological membrane such as the alveolar lining to possess such molecular architecture as to allow O_2 molecules freer passage in one direction and CO_2 molecules in the other, a heaping up of O_2 on one side and CO_2 on the opposite side would occur.

lens would be most marked, and the mechanical arrangement of the ocular muscles, have received exhaustive study, with the most satisfactory results.

The essential act of vision is, however, the stimulation of the rods and cones by light. Of this part of the process, however, little knowledge has been gained. Here, again, we are stopped from want of mechanical analogy as a guide to investigation. The process is now intracellular, and the methods employed up to this point seem useless wherewith to press further.

The rods and cones are sensitive to light; so are the pigment cells in the skin of a frog. In both cases we judge this by result; in the frog's pigment corpuscles the light falling upon them is followed by a dissipation of energy in the movement of these processes; in the case of the rods and cones, the result is the passage of a nerve impulse—a process of which we know little beyond the rate with which it travels along a nerve, and that it is associated with the dissipation of a small amount of electrical energy. The relationship of the one to the other is a question to be attempted in the future.

As a third example, I will briefly mention the nature of the evidence to prove that the law of conservation of energy holds for the living animal machine just as it does for any piece of ordinary mechanism. This I think one of the triumphs of the physiology of the last fifty years. Ever since the principle of the conservation of energy was established, physiologists have been endeavouring to ascertain whether this held good for animals, and whether an energy balance-sheet could be constructed for animals just as has been done by physicists for heat-engines.

The income of energy is in the form of the potential energy of the food stuffs taken; the output mostly heat and mechanical work, with a certain very small amount as sound and electrical energy. The potential energy set free by the oxidisation of the food taken can be determined so that the total incoming energy over any period can be ascertained. Again, by placing an animal in a calorimeter, the whole of the output of energy can be measured as heat.

In some such way the applicability of the general law of the conservation of energy has been frequently tested, but the results have until recently been insufficiently accurate to balance. A physiological experiment of this kind is extremely complicated, and the possible sources of fallacy are very considerable. Many additional data have to be ascertained for the following reasons:—(1.) The *whole* of the food eaten does not enter the body at all. (2.) The *whole* energy of the food absorbed is not utilised, but much of it is excreted in a form still possessed of considerable potential energy. Consequently, the potential energy of the forces representing the unutilised portion of the food, and the energy

still left in the incompletely oxidised bodies excreted in the urine (urea) must be deducted from the amount originally present in the food. Further, air must be passed through the calorimeter for the animal to breathe. This becomes heated and saturated by moisture, and the amount of heat so lost must be determined.

Within the last few years Rubner has succeeded in overcoming all the experimental difficulties, and has obtained remarkably accurate results, which leave no doubt that the laws of conservation of energy apply equally well for animals as for much simpler mechanisms. The satisfactory determination of this point is of far-reaching importance. If the processes going on in an animal are regulated by such a fundamental law of physics, it is hard to conceive that the details of such processes, however impossible of interpretation by present knowledge of chemistry or physics, can be of an entirely different nature.

Of all progress during the last half-century, perhaps the most striking has been the increase in our knowledge concerning the nervous system. We are now able to locate with some accuracy the anatomical situations in the central nervous system, the integrity of which is essential to the performance of a particular function. We know, for instance, that in the higher animals certain superficial cerebral areas (the cortical areas) are fundamentally concerned with definite muscular acts of the opposite side of the body. Stimulation of such situations calls forth the corresponding movement, whereas destruction of these spots gives rise to paralysis, more or less lasting, of the voluntary expression of this movement.

Nor is this all; careful examination of monkeys which have had the so called cortical motor centres removed, shows that as well as definite paralysis of some of the movements of the opposite side of the body, they exhibit distinct blunting of sensation over the same area.

Other parts of the cerebral cortex have been found in the same way to be associated with the special senses, and the effects of disease in man have shown that a similar differentiation of nervous paths exists. The result of this kind of work, as well as possessing all the extraordinary interest attached to any discoveries concerning the nervous system, has been fruitful in providing facts which have been of immediate service in the domain of practical medicine.

Advance in knowledge of the nervous system has, however, been mainly anatomical. Much of what seemed an entangled mass of nerve-cells and their processes—nerve-fibres—of so great complexity as to baffle all attempts at unravelling, has slowly unfolded its scheme, after arduous research by new methods.

By the methods of anatomical research introduced by Waller and Flechsig, the arrangement of the nerve fibres into definite tracts, and the origin and distribution of these tracts has been discovered,

and Golgi's impregnation process has furnished brilliant results in discovering system and order in that nervous felt-work, the grey matter of the central nervous system. The method invented by Golgi has further demonstrated that the branches of one cell-unit are not continuous with those of another, but that they are in apposition.

Three fundamental facts of nerve physiology have been revealed :—

(1.) That if a stimulus be applied to any part of a nerve-cell-unit, although its axis cylinder process may be three feet in length, the effect of the stimulus is to start a nerve-impulse which travels upwards and downwards throughout the whole unit.

(2.) That the transfer of a nerve impulse from one nerve-cell-unit to another can take place in one direction only. Supposing A and B represent two nerve-cell-units, a stimulus applied to A arouses a nerve-impulse which spreads throughout A, and occasions a nerve-impulse which spreads throughout B. If, however, the stimulus be applied to B, the nerve impulse originated is incapable of causing a nerve impulse in A.

(3.) The rate at which a nerve-impulse travels along a nerve was measured in 1850 by Helmholtz, and is a little over a mile a minute, or rather faster than an express train.

Granted the fundamental physiological facts abovementioned and the anatomical knowledge of the relation of nerve-units to one another, one might expect to be able to predict what the path travelled by a nerve-impulse started in any particular area shall be, and hence what muscular response shall eventuate.

In the case of some simpler reflex phenomena of the spinal cord we can indeed in a general way predict what result shall follow stimulation of a sensory nerve in a particular area. Even in such a case, however, the nerve impulse has to leave the nerve-unit in which it originated and pass to one or more other nerve-units, and although we may be certain that this takes place, we are at present unable to state how it takes place.

Recent histological methods lead one to infer that, at any rate, in the dead and hardened nervous tissue there exists no absolute continuity between the processes of one nerve-cell and another. Physiological continuity must exist at the time a nerve impulse passes from the one to another, for all observations show how essential continuity of an irritable tissue is for conduction.

Again, although one may roughly predict the direction in which a stimulus applied to a sensory nerve will be expressed in the simpler reflex actions of the spinal cord, when the reflex necessitates the co-operation of the more complexly arranged

nerve-units of the brain it is no longer possible to predict what will be the ultimate expression and what will be the course travelled by the nerve-impulse. The same stimulus apparently spreads one time along one path, at another in a different direction. It appears as if the path between one nerve-unit and another were not constant, but that under different sets of circumstances continuity were effected between different units, thereby necessitating the nerve impulse taking a varying course with varied result according to circumstances.

One is so continually studying the relation of nerve-cells to one another in hardened and impregnated specimens, and, consequently, perhaps liable to forget that nerve-cells are alive and may manifest some further activities common to living things as well as being highly differentiated conducting tissue. The response to stimulus by the generation and propagation of nerve-impulse may not be the only outcome of their irritability, and they may be capable of limited movement.

In this regard I may mention a highly suggestive observation of Wiedersheim upon the cranial ganglia of a small transparent crustacean. As Wiedersheim examined this small creature under the microscope he noticed that at the time it was manifesting active muscular movement the ganglion cells were themselves motile and increased and diminished the length of some of their processes, much in the way of pseudopodia on a limited scale.

This observation, if confirmed, may be the key to the understanding of the continuity of nerve-units one with another. If the shorter processes of nerve-cells are possessed of limited movement, this movement may easily accomplish a continuity at the time a stimulus reaches the nerve-cell, and the differential result of the movement of more than one nerve-cell may be a possible interpretation of the variable course a nerve-impulse takes, and also of the hitherto unexplained phenomena of inhibition within the central nervous system.

The recent progress of knowledge of the nervous system has been mainly anatomical, and an immense amount of work must assuredly be done in the same field in the future, but for a great advance in understanding nervous processes we must look to the discovery of some more fundamental physiological facts. At present we are mostly in the dark both as regards the nature of nerve-impulse, and the physiological relation of one nerve unit to another. Fundamental nervous phenomena must be essentially identical in all animals, and the observations of Wiedersheim show that a study of these in the lowly animals might be productive of fine results.

The four instances of the kind of work physiologists have been doing of late years are, I think, fairly typical. From them you will see that a great deal of it has been minutely anatomical, and

that the remainder has mostly been concerned with the more simple, mechanical, and chemical processes which are associated with the lives of higher animals. In the case of respiration we know a great deal about the ways and means by which oxygen is brought to the cells, but of just what happens when cells take up oxygen and how they do it we are ignorant. We only know that when once they have it they keep it somehow combined, and are capable of exhibiting activity and of continuing to give off CO_2 for some limited period after they are deprived of oxygen.

Our knowledge of the anatomy and mechanical principles of the eye is more perfect than that of any department of physiology, but to understand vision we would like to know next something more regarding the mechanism by means of which the varying intensity and pitch of light, focussed upon the rods and cones of the retina as an inverted image of the object, originates a series of nerve-impulses in these sensitive cell-units.

It is of the utmost importance, I think, that we should have obtained satisfactory evidence that notwithstanding all the complications of vitality, that a living animal is subservient to the principle of the conservation of energy just as an ordinary machine. We can trace the food possessed of potential energy of chemical composition through some slight transformations, until it reaches the cell, and we can trace the more or less fully oxidised products which have given up that energy, away out of the body; but here, just as in the other instances, the details of the transformation itself are intracellular and for the present hidden.

The acquisition of knowledge of the structural arrangement in the nervous system has been considerable, whereas regarding the nature of nerve-impulse and the behaviour of nerve-cells during nervous activity we know little or nothing. For the past fifty years physiologists have been principally concerned with the analysis of the function of organs as such, and have more or less left aside the physiology of cells. In my opinion they have been quite wise in so doing. In this way all those physiological phenomena which can be measured according to physical standard and interpreted in terms of physics and chemistry have, to a large extent, been separated off from those that cannot. Processes in which cells participate collectively as membranes or organs have been more or less sharply defined from those in which they operate by means of their individuality, and in which cases the phenomena are intracellular. Surely it was wise to ascertain to what extent a physiological result was due to the physical or chemical properties of the matter concerned, in order to know at what point the intervention of cellular activities is necessary.

Mechanical and chemical analogy are of limited service in the interpretation of intracellular activities; indeed it has not infrequently been stated that we are wasting our time in attempting

the study of vital processes by such means. It is quite true that the chemistry and physics of to-day are totally unable to throw any ray of light upon such biological phenomena as growth and heredity, and it may appear sanguine to imagine that the chemistry of the future ever will do so.

The great and fundamental distinction between the growth of an unorganised body and a living cell is that whereas a crystal of any definite substance can only grow by the aggregation of similar molecules of the same substance, in the growth of a cell the cell draws upon totally dissimilar molecules, and by some unknown property converts them into molecules of similar constitution to itself. The living cell, in fact, possesses the power of assimilation, which is the fundamental distinguishing characteristic from all that is not living.

It is well, however, to remember that not very many years ago the belief in the impossibility of synthesising organic bodies, such as urea and sugars, was universal, and the formation of these bodies was supposed to necessitate the operation of "vital force." Wohler showed how easily urea may be built up from its elements, and the fine work of the brothers Fischer has demonstrated not only the possibility of manufacturing the various sugars in the laboratory, but also some suggestive insight into the probable details of the synthesis of carbohydrates by plants.

Professor Foster, in his British Association address at Toronto, 1897, reproached the chemists for having lagged behind in attacking just those chemical problems, some light upon which would be so gratefully received by their physiological brethren. Would that the chemists would assist us in understanding the chemical properties of proteids and other bodies possessed of huge molecular weight, or provide us with a chemical interpretation of the details of the action of ferments. But the chemists are loath to undertake the investigation of substances which they cannot crystallise or even prepare in a pure condition, and of which they cannot ascertain the molecular weight. For this we cannot blame them. I think they are finding the interpretation of chemical relationships sufficiently complex even among bodies with which they can start upon so sure a basis, and are wise in confining their attention for the present to problems which they can attack upon general chemical principles. Meanwhile, the chemical investigations of essential importance to biologists have, in spite of their inexactitude, of necessity been taken up by physiologists.

During recent years, however, larger numbers of physiologists, and among them some of the best, have been devoting their attention to the elementary phenomena exhibited by cellular activity. Acting upon the conviction that these are essentially identical in all cells, Engelmann, Budimann, Verworn, Loeb, and a host of others have been attacking problems of cellular physiology by

experimenting with separated cells from multicellular organisms, and especially with unicellular animals and plants. By such means we may hope to discover some general laws regulating the activities of protoplasm. At the same time, the number of researches upon the more lowly animals belonging to the invertebrata is rapidly increasing. The physical properties of protoplasm, such as consistence, specific gravity, optical properties, have been re-examined, and the first disintegration products of the destruction of protoplasm are beginning to be studied with renewed vigour with the object of ascertaining what special molecular arrangement may be characteristic of living matter.

The intimate structure of cells is becoming of equal importance to the physiologist as to the morphologist. All the detailed changes of structure in cell and nucleus which may be manifested during activity, whether it be division of the cell, fertilisation, or secretion, are being assiduously studied. Interesting changes in the chemical properties of different parts of the cell-nucleus and nucleolus, as shown by alteration in their reaction to various staining agents have been carefully observed. Some rough idea of the difference in chemical composition of different parts of the cell has been ascertained, as, for instance, the increased amount of phosphorus-containing compounds in nuclei. We know also that the chromatin is largely composed of nucleins, whereas the nuclear-sap is made up of some other albuminous matter.

Another series of observations which will likely prove of much value are concerned with the response of cells to different kinds of stimuli, chemical, mechanical, electrical, light, gravity, &c. The study of chemotaxis, the name given to the movements of a cell, animal or vegetable, towards or away from the presence of small quantities of some chemical body, has already assisted greatly in our understanding of inflammation, that protective reaction of an animal against the introduction of noxious material from without. Chemotaxis also plays a part in the fertilisation of ferns and mosses. Slight traces of some body are dissolved out of the female organs. This attracts the spermatozoids and directs their movements towards the position of greatest concentration, viz., the neighbourhood of the female cells. Some such directing force may operate in bringing the spermatozoa of animals into contact with the ova. This may apply alike in those cases where both are discharged free into the water, and also where the spermatozoa ascend the oviducts against ciliary action. The effects of alteration in temperature, desiccation, and changed environment generally upon all kinds of organisms are being assiduously studied, and everywhere increased attention is devoted to the elementary phenomena of living things, and just as the physiology of the last half century has been essentially an organ-physiology, the new departure must be characterised as a cellular-physiology.

In sketching the progress of morphology during the last fifty years, I pointed out how the inconsistency in view which divided biology into two sections disappeared with the old teleology. Also how of late years attention has been directed to the cell as the morphological unit, and how morphologists have been greatly interested in the manifestations of cellular activity which are concerned in growth and heredity.

The physiologists, too, having studied the chemistry and physics of phenomena associated with the life of higher animals, have tracked physiological activity into the cell. Here, for the time being, a view of the mechanism is lost, and cellular physiology does not appear capable of being successfully attacked along the same lines of mechanical interpretation which have proved so successful in dealing with the functions of compound organs.

The full recognition of the cell as the physiological unit, and the study of cellular activity from every side has already yielded valuable results, and shows every indication of being the direction of future biological progress.

One must not imagine that the morphological or physiological inquiry of the character which has been so fruitfully prosecuted during the last half-century is in any sense exhausted. Enough has been done, however, to disclose their limitations as far as a complete understanding of life is concerned. Enterprising thinkers have, therefore, been considering new methods of attacking the problem.

It is just in this fresh attack upon biology that the adherents of the two great divisions of biological inquiry—students of form and students of function—find themselves side by side, and discover that, after all, though under different names, they have both been striving at much the same object—viz., the interpretation of living activities.

BOTANICAL PAPERS.

No. 1.—A FEW WORDS ABOUT THE FLORA OF THE ISLANDS OF TORRES STRAITS AND THE MAINLAND ABOUT SOMERSET.

By F. Manson Bailey, F.L.S., Colonial Botanist for Queensland.

(Read Friday, January 7, 1898.)

In June last it was my good fortune to spend three weeks in the above northern portions of Queensland, and by the kind assistance of the Government Resident, the Hon. John Douglas, C.M.G., I was enabled to visit Goode Island, Hammond Island, Turtle

Island, besides Somerset, on the mainland, which, with the longer stay on Thursday Island, gave me a fair view of the flora of these parts. However, the time of my visit was not a very favourable one, for the plants of all kinds were suffering greatly for want of rain, there having been very little rain during what in these parts is called the wet season. This want was not so badly felt on the mainland, and here I found the flora particularly rich and interesting, and I feel no hesitation in saying that a large number of hitherto undescribed plants are here waiting the hand of the botanical collector. Besides those which may prove new, there are many others, the published descriptions of which are far from being complete. The palms of this district are beautiful, and probably numerous in species; but these require very careful collecting, so that the flowers, fruit, and foliage of each kind may be kept separate. During my few days' stay I obtained what I consider two new species, as well as two new species of *Nepenthes*. These latter Mr. F. L. Jardine had brought in for me from some distance. He also described to me another of these curious plants which I think in all probability is also new, and should this prove the case, the Queensland flora will contain five species of this remarkable genus. Amongst the very many plants of this locality which I should much like to be brought into garden culture is *Morinda reticulata*, Benth. This plant forms a compact shrub about 3 or 4 feet in height, and nearly every branch is crowned with a head of white flowers, the beauty of which is enhanced by the number of large white bracts by which each head is often surrounded. The specimens from which the author of the "Flora Australiensis" drew up the description for that work were those gathered by A. Cunningham on the north-east coast, and some obtained by W. Hill on Albany Island, since which Baron Mueller records having received specimens from Fitzroy Island and the Endeavour River, but adds nothing to the description above quoted, which might be extended to read:

M. reticulata, Benth., a broadly-spreading glabrous shrub, rarely exceeding 3 feet in height, the upper internodes rather long, smooth, and cane-like. Leaves coriaceous, broadly ovate, sometimes acuminate, the larger ones often 6 inches long and 4 inches broad, the pinnate veins and reticulate veinlets very prominent. Stipules broadly triangular and acute. Peduncles about 1 inch long, four together, terminal or in the upper axils, each bearing a head of about ten flowers. Calyx tubes partly emersed in the receptacle, the teeth or lobes minute, except some of the outer ones of each head of flowers, which develop into petiolate white bracts nearly the size and with the same form and venation as the stem-leaves. Corolla tube 6 lines long, very hairy at the orifice; lobes oblong, about 3 lines long; anthers slightly exerted; style not

much exerted, with short stigmatic lobes; fruit forming an irregular shaped depressed syncarp 1 to $1\frac{3}{4}$ inch wide; seeds, two in each perfect carpel, silky, elliptic-oblong, about 5 lines long. Hab., Polo Creek, Somerset.

Amongst the large climbers the anonaceous plant *Uvaria membranacea*, Benth., was the most attractive from its bunches of rich coloured fruit. The leaves, I found, attained a much larger size than stated in the "Flora Australiensis," and often are seen nearly 1 foot long. The fruit, which has not been described, consists of a number of long-stalked, oblong, deep scarlet carpels, borne upon a rather large globose receptacle, each carpel often exceeding $1\frac{1}{2}$ inch in length and nearly 1 inch in diameter. The seeds, which are embedded in a sweet pulp, are of an oblong or lenticular form, with a more or less prominent border, and measure about 5 lines in diameter. In company with this was another red-berried plant, *Tinospora smilacina*, Benth., of the "Moonseed family" (*Menispermaceæ*), but at first sight it might be mistaken for one of the peppers.

Besides the large number of trees, shrubs, &c., forming the flora of this northern portion of the peninsula, which have a value on account of their great beauty, others, probably many, may possess a commercial value; and, now that so great a demand has arisen for "rubber," it might be well to test some of our Queensland plants for this product, particularly those belonging to the orders *Urticaceæ* (as the numerous fig-trees) and *Apocynaceæ*. A tree of this latter order is very plentiful in the scrubs under notice. I have not seen flowers or ripe fruit, but believe it to be a new species of *Alstonia*, and, under the name *A. somersetensis*, have recorded it in the September, 1897, number of "The Queensland Agricultural Journal." I found the tree, although not in growth, give out a copious flow of milk-sap, so we may naturally expect the flow of sap to be much greater during the summer. I saw also some rhizomes, at Mr. Jardine's, of an excellent almost fibreless ginger, which that gentleman assured me was indigenous.

While at Somerset I took the opportunity of visiting Turtle Island, which is situated about 12 miles further south. My object was to find, if possible, Robert Brown's *Calostemma album*. In this I was not successful; but, upon the dry sand patches, found dry stems of a *Tacca*, which must, when growing, have stood over 5 feet high. On this island the trees are few and stunted. One, an *Erythrina*, I think undescribed, and have given to it the name *E. insularis*, and have distributed the seed obtained under that name. The other trees were kinds most usually found in similar situations, as *Hibiscus tiliaceus*, Linn.; *Micromelum pubescens*, Blume; *Brassaia actinophylla*, Endl.; *Mackinlaya macrosciadia* F.v.M.; *Guettarda speciosa*, Linn; *Mimusops Browniana*, Benth.; and *Macaranga Tanarius*, Muell. Arg. The smaller plants were,

for the most part, dried up past recognition. A Crinum, which I detected by the dry foliage, lying flat upon the ground, may prove of interest; the bulbs were very large, and I am in hopes of those I obtained producing flowers during the present summer.

On the islands in the Straits I certainly expected to meet with a more diversified flora than I saw there, and probably on the larger islands, could the time have been spared to make a careful botanical examination, many new plants would have been brought to our knowledge. The prevailing high winds are detrimental to the growth of tall, handsome trees, thus no trees of any considerable size are met with except in the deep gullies between the hills. These trees principally consist of *Buchanania Muelleri*, Engl.; *Semecarpus Anacardium*, Linn.; *Erythrina indica; Albizzia procera*, Benth.; and *Barringtonia racemosa*, Gaudich. On the hills and other exposed situations were *Eucalyptus clavigera*, A. Cunn., and *E. corymbosa*, Sm., but the tree most generally met with, and the one which seems to thrive best, is *Tristania longivalvis*, F.v.M. This has a bright green foliage and a profusion of yellow buttercup-like blossoms, the petals of which are as fugacious as those of the peach. Amongst smaller trees three acacias meet one everywhere, viz., *A. Simsii*, A. Cunn., of graceful growth and long narrow leaves and slender flower spikes, *A. leptocarpa*, A. Cunn, with glabrous, long, falcate leaves are of a dark colour, and *A. Cunninghamii*, Hook. This seems the commonest of the three, and is the hoary-pubescent form of the species. With these also are seen trees of *Sterculia quadrifida*, R.Br., the "Nonda," *Parinarium Nonda*, F.v.M., and the useful shade trees, *Terminalia Catappa*, Linn., and *T. platyphylla* F.v.M., the first of which is also of some value as a fruit and oil producer. *Diplanthera tetraphylla*, R.Br., which in the scrubs about Rockingham Bay forms one of the largest trees, is here quite dwarf, the largest I met with being scarcely 20 feet high, but beautifully in flower; the flowers of these island trees of this species about equalled those on the mainland, but the leaves were scarcely more than a third of the size, for I find from an entry in an old note-book that in May, 1873, I measured leaves of this tree growing on the Herbert River, which were 25 inches long and 13 inches broad. The difference in size takes place also in the size of the foliage of *Gmelina macrophylla*, Benth., growing at Somerset and Thursday Islands. The trees or large shrubs which are found nearest to the mangroves are mostly *Cochlospermum Gillivrai*, Benth., which produces yellow flowers of some beauty, but is very scanty of leaves; *Melaleuca symphyocarpa*, F.v.M.; *Eugenia carissoides*, F.v.M.; *Pemphis acidula*, Forst.; *Guettarda speciosa*, Linn.; and *Premna obtusifolia*, R.Br., which has somewhat round large leaves; *Clerodendron inerme*, R.Br.; and the universal tropical coast tree, *Thespesia populnea*, Corr., which in other countries is made to serve many

useful purposes, but with us is entirely neglected. What might be termed the mangrove flora of these islands scarcely differs from that of the mainland. Here, however, and at Somerset I frequently met with trees of the yellow plum (*Ximenia americana*, Linn.) The fruit, which is about the size of a pigeon's egg, is agreeable to the eye, but very insipid. Of climbing-plants the order *Convolvulaceæ* or "Morning Glory" family furnish the greatest number of species, the flowers of which are large and showy; *Cassytha filiformis*, Linn., one of the "Laurel Dodders," is seen in every direction crowding over every tree and shrub, and, when nothing else is near, fixing upon even the grasses, out of which also it sucks the life. Writers tell us that in India this pest enjoys a reputation for medicinal virtues; let us hope that, ere long, some of our "medicine men" may discover a use for it, and that the demand may act as a check upon its spread. Climbing over shrubs near the beach may be seen plants of *Modecca australis*, R.Br. The genus is allied to the passion-flower, and the species are worthy of garden culture on account of the bright-red fruits which are in this island species blunt, almost truncate at the end, thus differing from *M. populifolia*, Blume, the species met with in the scrubs of the Barron and Endeavour Rivers, which is much longer, narrower, and spindle-shaped. In one of the gully scrubs of Thursday Island I found plants of a weak climbing cucurbitaceous plant, which I take for a *Melothria*, but was only able to obtain fruiting specimens. It attracted my attention from the manner in which it ejects its seeds, which is precisely that of the squirting cucumber (*Ecbalium elaterium*, A. Rich.) The fruits were scarcely the size of a pigeon's egg. I am in hopes of raising plants from the seeds obtained, from which the species may be determined. The beautiful orchids for which these islands used to be favoured are fast disappearing, at least from anywhere easy of approach from Thursday Island—such is the case with regard to the varieties of *Dendrobium bigibbum*, Lindl., which are the kinds most sought after. On the trees of Hammond Island I saw large masses of that pitcher-forming *Asclepiad*, *Dischidia Rafflesiana*, Wall., as well as the other species of this genus, which in Queensland are known as "Button Orchids."

At the time of my visit the small plants, such as annuals, herbaceous plants, and small shrubs, owing to the unusual dry weather, were only found in bloom on a few favoured spots. Patches were often seen of *Tephrosia polyzyga*, F.v.M., with its nodding racemes of small, purplish flowers, and long leaves, which are composed of numerous small leaflets. In company with this plant may in places be seen *Jacksonia thesioides*, A. Cunn. This forms a very pretty shrub, rather dense, of about 3 or 4 feet in height, of a pleasing gray colour; the flowers are of a very pale-blue, small, but numerous. On the sandy land near the beach at

Goode Island, the place was made bright and gay by a thick growth of *Gomphrena flaccida*, R.Br., and a taller growth of *Plumbago zeylanica*, Linn. On Thursday Island and Hammond Island all damp spots were made gay by the pretty, pure white flowers of *Buchnera tetragona*, R.Br., and other species of this genus; the blue flowers of *Lobelia Douglasiana*, Bail., and *Wahlenbergia gracilis*, A.DC.; the neat little *Vandellia alsinoides*, Benth., and *Stylidium uliginosum*, Swartz., and the curious "Sundew" *Drosera indica*, Linn., with its rosy flowers, and long, narrow, often-curled, glandular leaves. One of the brightest flowers of these islands is *Hæmodorum coccineum*, R.Br., which is found amongst the broken rocks on the sides near the base of the hills; the leaves are grass-like, and the flowers, which are of a deep, red colour, are borne in broad, terminal panicles; the species is one well worthy of garden culture. In the shady scrubs the ground was brightened by the flowers of *Asystasia australasica*, Bail., and other *Acanthaceæ*.

A SKETCH OF THE THURSDAY ISLAND FLORA.

This enumeration of Thursday Island plants which were observed by myself during last June, and to which I have added those that have at various times reached me for determination, and also those recorded by other botanists as indigenous on the island, is given as a basis upon which a flora might be compiled by some resident there having the leisure for the work. The flora of all the islands of Torres Straits will, I think, be found to be very similar, differing according to the amount of moisture; those situated like Thursday Island, wanting a permanent water supply, having the smaller number of species. This difference, however, may not be so great as it appears at first to persons paying a visit at the dry season or during a drought, for there is quite time enough during the wet season, and the time it would take to exhaust the supply of moisture from rainfall in the ground, for a large number of plants to spring up and pass through all their stages of existence on islands wanting a permanent water supply, whereas on the more favoured islands these same plants may be met with on the damp land all the year round.

Where I have not seen the plant on the island, but have received specimens from others, or find the habitat recorded by other botanists, the name of collector or recorder is given in parenthesis.

DYCOTYLEDONS.

Menispermaceæ. (Moonseed Family.)

Tinospora smilacina, Benth.

A glabrous twiner, with leaves somewhat resembling those of a Sarsaparilla (*Smilax*) or Pepper vine (*Piper*), and short racemes of red drupes. Ripe in June. (E. Cowley, 1893).

Stephania hernandiæfolia, Walp.

A more or less pubescent twiner, with almost orbicular peltate leaves. Fruit red, compressed, in umbels of about 5 rays. Ripe June.

Violarieæ. (Violet Family.)

Ionidium suffruticosum, Ging.

A weak undershrub, having the lower petal of each flower purplish and much larger than the others. Usually met with under the shade of trees or shrubs. Flowers June.

Bixineæ. (Arnatto Family.)

Cochlospermum Gillivræi, Benth.

A tall shrub, bearing open yellow flowers 2 inches diameter, followed by obovoid-oblong capsules; leaves palmately lobed, but the plant scanty of foliage. Flowers June.

Polygaleæ. (Milkwort Family.)

Polygala arvensis, var. "Field Milkwort."

A weedy plant a few inches high.

Caryophylleæ. (Pink Family.)

Polycarpæa breviflora, F. v. M.

A light-coloured weed, met with on dry hard soil.

Portulaceæ. (Purslane Family.)

Calandrinia spergularina, F. v. M.

A small succulent plant, met with on damp land.

Elatineæ. (Water Peppers.)

Bergia ammannioides, Roth.

A hairy plant, 6 to 12 inches high; flowers minute, in dense clusters, in the axils of the leaves. (E. Palmer).

Hypericineæ. (St. John's Wort Family.)

Hypericum gramineum, Forst. "Australian St. John's Wort."

A small erect plant, with narrow oblong leaves and yellow flowers.

Malvaceæ. (Mallow Family.)

Malvastrum spicatum, A. Gray.

A common weed in Queensland.

Sida rhombifolia, Linn.

The common Sida weed.

Abutilon indicum, G. Don. "Wild Chinese Lantern."

A showy soft shrub, flowers yellow (June).

Urena lobata, Linn. var. "Cæsar weed of America."

A tall shrub with rosy flowers, sometimes a weed in cultivation (June).

Hibiscus radiatus, Cav.

An erect plant of 2 or 3 feet, leaves lobed, flowers white with dark centre (June).

Thespesia populnea, Corr. "Tulip-tree of India, or Seaside Mahoe."

A small tree met with near the beach, with broad, heart-shaped leaves, and rather large Hibiscus-like yellow flowers, capsule hard, round (June).

Sterculiaceæ. (Bottle-tree Family).

Sterculia quadrifida, R.Br.

The island trees are stunted in growth, but the leaves seem larger, and the fruit smaller than on the mainland trees.

Heritiera littoralis, Ait. "Red Mangrove or Looking-glass Tree."

A small sea coast tree, with oblong leaves silvery on the under side; the hard woody ovoid fruit about 3 inches long, often seen washed about by the tide.

Tiliaceæ. (Linden-tree Family.)

Grewia polygama, Roxb. "Kooline" of the Cloncurry natives (E. Palmer); by some the fruit is called emu berry.

A small shrub; the fruit used by the aborigines for food.

Triumfetta rhomboidea, Jacq. "Chinese Burr."

A weed, probably an introduction.

Corchorus acutangulus, Lam.

A weedy, spreading undershrub, with minute yellow flowers, and longitudinally winged capsules.

Geraniaceæ. (Geranium Family.)

Oxalis corniculata, Linn. "Sour grass, or yellow wood-sorrel."

A common weed, varying considerably in the size of leaf and flower.

Rutaceæ. (Rue Family.)

Micromelum pubescens, Blume.

A small pubescent tree with pinnate foliage. The fruit in terminal broad corymbs, ovoid, from yellow to red, according to the stage of ripeness.

Simarubeæ. (Quassia Family.)

Suriana maritima, Linn.

A more or less hoary shrub, the leaves linear-spathulate, about 1 inch long, flowers yellow, drupes minutely pubescent, small (W. Bauerlen, 1885).

Meliaceæ. (Bead-tree Family.)

Carapa moluccensis, Lam.

A glabrous tree found growing with the mangroves. Fruit irregularly globose, somewhat resembling a citron, containing several large angular seeds.

Olacineæ. (Olax Family.)

Ximenia americana, Linn. "Yellow Plum."

A rambling shrub, grows just above high-water mark, scanty of foliage, leaves oval, the largest scarcely 2 inches long. Flowers axillary, greenish; sepals four, minute; petals four, 4 or 5 lines long, recurved, very hairy on the inner side. Stamens 8, filaments crooked; anthers large. Fruit roundish-oval, about 1-in. diameter with a thin pericarp, and very light coloured, smooth, bony endocarp. This form or species in my opinion should be kept distinct from the inland plant. Fruit ripe in June.

Rhamneæ. (Buckthorn Family.)

Zizyphus Ænoplia, Mill. "Vinous Jujube."

A large rambling shrub, the young branches often rusty-pubescent, spines short, one of each pair straight and deciduous. Drupes globular about 3 lines diameter. Met with in the gully scrubs. Fruit ripe in June.

Alphitonia excelsa, Reissek. "Red Ash."

A small erect tree, leaves varying from lanceolate to nearly orbicular. Flowers forming terminal corymbose panicles. Fruit globular. Found on hillsides. In some parts of Queensland the leaves are used by school children to remove ink-stains from their hands. A few leaves rubbed in water soon produces a strong lather.

Ampelideæ. (Grape Family.)

Vitis trifolia, Linn. "One of the Native Grapes."

A climber, leaves of three leaflets; berry small depressed-globular, found on the border of scrubs.

Leea sambucina, Willd.

A tall shrub with large twice or thrice pinnate leaves; and wide spreading panicles of four to six seeded brown berries.

Sapindaceæ. (Soapberry Family.)

Dodonæa viscosa, Linn. "The Sticky Hop-bush."

The form most generally met with in the tropics. The leaves with prominent veins.

Anacardiaceæ. (Marking-nut Family.)

Buchanania Muelleri, Engler.

Tree with widely spreading head, a common tree of all the islands. Flowers white, small, in short spreading panicles at the ends of the branchlets. Fruit compressed, about ½ inch long. Flowering in June.

Semecarpus australiensis, Engler. "Australian Marking-nut Tree."

A tree of considerable size. Leaves somewhat oblong, pale on the underside. Fleshy footstalk of fruit, from almost a yellow to a bright red colour, often used as a fruit. It is the acrid oily juice of the true fruit that is used for marking.

Leguminosæ. (Pulse Family.)

Jacksonia thesioides, A. Cunn.

A neat little shrub worthy of garden culture; flowers, pale-blue; found on hill sides. Flowering in June.

Crotalaria linifolia, Linn. "Flax-leaved Rattle-pod."

C. calycina, Schranck. "Shaggy Rattle-pod."

C. trifoliastrum, Willd.

C. incana, Linn. "Hoary Rattle-pod."

The above four rattle pods are plants of a weedy growth, having yellow flowers.

Indigofera linifolia, Retz. "Flax-leaved Indigo."

A procumbent plant, easily known by its minute white round pods.

I. hirsuta, Linn. "Hairy Indigo."

An annual plant, 1 or 2 feet high with red flowers; pods nearly 1 inch long, quadrangular.

Tephrosia polyzyga, F. v. M.

A slender undershrub of several feet, the leaves with numerous leaflets. Flowers in June.

Smithia conferta, Lam.

A small procumbent plant, the leaves of 7–15 leaflets; the flowers in clusters; a weedy plant.

Zornia diphylla, Pers.

A decumbent weedy plant with leaves of 2–leaflets.

Desmodium umbellatum, DC.

A weak shrub, attaining with the support of other shrubs the height of 6 or more feet. Pods of three or four thickish articles.

Abrus precatorius, Linn. "Crabs'-eyes, or Wild Liquorice."

A climber, well-known by its seeds, which are red with a black spot.

Erythrina indica, Lam. "Coral-tree."

A tall deciduous tree met with near the top of the gullies between the hills.

Mucuna gigantea, DC. "Black Bean."

A scrub climber, flowers greenish, rather large, at the end of a long stalk; seeds black. The northern plants seem to have somewhat smaller flowers, and the seeds are not so flat as those of the southern plants. Flowers June.

Canavalia obtusifolia, DC. "Coast Bean."

A coast bean with rather showy pink flowers. Flowers June.

Dalbergia densa, Benth.

A rambling, sometimes climbing, shrub, with clusters of very small flowers; common everywhere on the island. Flowers June.

Entada scandens, Benth. "Matchbox Bean."

Probably the largest climber of Australia. I saw no plants of this on the island, but Mr. E. Palmer noticed it there about ten years ago; and also says that at the Endeavour River the natives roast or bake the beans, then pound them fine, put in dilly-bags, and place in water for about ten hours before using for food.

Cassia mimosoides, Linn.

A common erect weed, 1 or 2 feet high, with yellow flowers, found amongst grass.

Acacia Simsii, A. Cunn.

A tall slender shrub with long narrow leaves.

A. Cunninghamii, Hook., var.

The hoary form of this common wattle, a small tree.

A. leptocarpa, A. Cunn. This has dark green foliage.

The three species mentioned are the common Acacias of the island.

Albizzia procera, Benth.

This is one of the tallest trees on the island, and found growing in the highest parts of the gully scrubs.

Rosaceæ. (Rose Family.)

Parinarium Nonda, F.v.M. "Nonda Tree." Native name on the Mitchell, *Yuley*. (E. Palmer.)

A handsome round-headed small tree, with oval more or less downy leaves, and yellow oval edible fruit about 1½ in. long; met with on the flat land; fruit ripe in June. Mr. Palmer says this tree represents one of the clans of the Mitchell blacks.

Droseraceæ. (Sundew Family.)

Drosera indica, Linn. "Sundew."

This species is found on the damp land. Mr. E. Palmer tells us that the plant is used by the young blacks to rub on their faces to make whiskers grow.

Rhizophoreæ. (Mangrove Family.)

Rhizophora mucronata, Linn. "Common Mangrove."

Calyx-segments and petals, 4; stamens, 8 to 12.

Ceriops Candolleana, Arn. "Small-leaved Mangrove."

Calyx-segments and petals, 5 or 6; stamens twice as many as petals.

Bruguiera Rheedii, Blume. "Red Mangrove."

Calyx-segments and petals usually 12; stamens twice as many as petals.

Combretaceæ. (Combretum Family.)

Terminalia catappa, Linn. "Country Almond."

A tree usually met with upon the beach, head spreading, leaves large, fruit eatable, yellow when ripe, with a somewhat fleshy exocarp.

T. platyphylla, F. v. M. "Durin" of the Flinders blacks. (E. Palmer.)

A hoary shade tree, very plentiful on the island; fruit oval.

Lumnitzera racemosa, Willd.

A small tree found in company with mangroves; leaves 1 or 2 inches long, tapering to the base; flowers scarlet, in dense racemes, sometimes few. (Hon. John Douglas, 1888.)

Myrtaceæ. (Myrtle Family.)

Melaleuca symphyocarpa, F. v. M. "A tea-tree"

A tall bushy shrub, leaves 1 or 2 inches long, flat, many-nerved. Flowers in globular heads on the old wood. Found on low land.

M. leucadendron, var. Cunninghamii, "Broad leaved tea-tree."

A tall shrub with very broad leaves. Flowers of one form, dark-red, of another yellowish. Usually found on swampy land.

Eucalyptus clavigera, A. Cunn.

Of somewhat similar growth to the Island Bloodwood, but with more spreading head.

E. corymbosa, Sm. "Bloodwood."

The trees of this species are very stunted on the island.

Tristania longivalvis, F. v. M. "Buttercup tree."

The handsomest tree on the Island, and met with everywhere. Flowers abundant, yellow.

Fenzlia obtusa, Endl.

A neat shrub of 3 to 5 ft., with hoary oblong leaves, and purplish flowers; met with on low sandy land.

Eugenia carissoides, F. v. M.

A shrub of 5 or 6 ft. high, with almost orbicular leaves. Flowers few or solitary, often on the old wood, near the beach.

Barringtonia racemosa, Gaudich. "Freshwater Mangrove."

One of the largest trees of the Island; on young trees the leaves are large; flowers of a pale-pink; bruised barked used by the natives to poison fish. (E. Palmer.)

Plenty of the fruits of *B. speciosa*, R. and G. Forst., was seen washing about the beach, but I met with no trees.

Lythrarieæ. (Loose-strife Family.)

Pemphis acidula, Forst.

A tall dense shrub of the coast; leaves oblong, about ½ in. long; flowers axillary.

Lagerstræmia? Flos-Reginæ, Retz, "Queen's Flower."

I found a tall shrub of what may be the East Indian tree, with plenty of seed capsules upon it, but am not sure of its being indigenous, although it was growing away from any habitation.

Onagrarieæ. (Evening Primrose Family.)

Ludwigia parviflora, Roxb.

A weed of wet land.

Passifloreæ. (Granadilla Family.)

Passiflora aurantia, Forst. "Passion-flower."

A very pretty native climber, the colour of flowers variable.

Modecca australis, R. Br.

The flowers of this climber are poor, but the bright scarlet fruits and clean large leaves make up for the want of beauty of flowers.

Cucurbitaceæ. (Gourd Family.)

Luffa ægyptiaca, var. *peramara*. "The bitter sponge-gourd."

A tall climber of the scrubs, flowers rather large, yellow; used in a green state to poison fish. (E. Palmer.)

Mukia scabrella, Arn.

A slender scabrous climber, with small yellow flowers and globular fruits about ½ inch in diameter; found on the borders of the scrub.

Ficoideæ. (Pig's-face Family.)

Sesuvium portulacastrum, Linn.

A succulent, beach plant, with linear leaves 1 or 2 inches long, no petals, but the calyx-lobes pinkish and scarious on the margins.

Mollugo spergula, Linn.

A procumbent weedy plant on wet land.

Araliaceæ. (Ginseng Family.)

Brassaia actinophylla, Endl. "Umbrella tree."

I only met with a few stunted plants.

Rubiaceæ. (Madder Family.)

Hedyotis cærulescens, F.v.M.

A slender twiggy plant, with narrow linear leaves, met with on hill-sides.

Dentella repens, Forst.

A pretty little creeping plant, met with on damp land.

Guettarda speciosa, Linn.

A spreading tall shrub, met with about high-water mark. Flowers white, very deciduous. Fruit globular, hard, 1 inch in diameter.

Plectronia odorata, B. and H.

A tall shrub, with smooth ovate leaves. The fruit like small coffee berries; found near the beach. (E. Cowley, 1893.)

Cœlospermum reticulatum, Benth.

A very dry-looking shrub, with oval-oblong prominently reticulated leaves, small white flowers and small globular fruit. Near the beach.

Spermacoce lævigata, F.v.M. "Smooth button weed."

A very pretty undershrub with blue or white flowers in terminal heads. Met with on the sides of the hills. In flower June. Two varieties, white and blue.

Compositæ. (Aster Family.)

Vernonia cinerea, Less.

A rather pretty little plant, with purplish heads of flowers.

Vittadinia macrorrhiza, A. Gray.

A pretty plant 6 or 12 inches high, not very plentiful so far as I observed.

Blumea diffusa, R. Br.

A weak little annual, found on damp land; the radical leaves almost rosulate, the flower heads very small.

B. hieracifolia, DC.

A rather stiff plant, 1 foot or more high, met with on the hills.

Epaltes australis, Less.

A branching almost prostrate plant, common on wet land, flower-heads in the forks of the branches ; an uninteresting weed.

Phacelothrix cladochæta, F.v.M.

A small annual weed (F.v.M.)

Rutidosis Brownii, Benth.

A small more or less cottony plant (E. Cowley, 1893).

Wedelia calendulacea, Less.

A decumbent plant, with rather large yellow heads of flowers.

W. urticifolia, DC.

A rough plant of 2 or 3 feet ; a bad weed ; flower-heads small on slender peduncles.

W. asperrima, Benth.

A bad weed, very harsh ; flowers often several together in a loose panicle.

Emilia purpurea, Cass.

A weak plant, flowers small, purple.

Dr. Lindley says—" Flora Medica "—that the decoction of the leaves is used in India as a febrifuge.

Stylideæ. (Hair-trigger-flower Family.)

Stylidium uliginosum, Sw. One of the hair-trigger plants.

A wet-land plant, leaves radical, scape erect, flowers pink.

Campanulaceæ. (Blue-bell Family.)

Lobelia Douglasiana, Bail., n. sp.

A pretty weak-stemmed blue flowering plant, common on damp land.

Wahlenbergia gracilis, A.DC. "The common blue bell."

Plumbagineæ. (Leadwort Family.)

Plumbago zeylanica, Linn. "Queensland leadwort."

Rare and poor, but on Goode Island very strong with unusually fine flowers.

Sapotaceæ. (Sapota Family.)

Lucuma sericea, Benth and Hook.

A small tree ; leaves oblong, ovate, 3 to $4\frac{1}{2}$ inches long, coriaceous, silky on the under side. Fruit ovoid, nearly 1 inch long ; seeds, one or two.

Mimusops Browniana, Benth.

A small tree ; leaves about 3 inches long, oval or nearly orbicular, whitish on the under-side. Fruit almost globular ; seeds, one or two, more or less compressed.

Oleaceæ. (Olive Family.)

Jasminum simplicifolium, Forst. "Native Jasmine."
A large, free flowering, woody climber, met with on the hills.

Apocynaceæ. (Dogbane Family.)

Alyxia spicata, R. Br. "Climbing Chain-fruit."
A large woody climber with a great quantity of milky sap. Flowers small in pedunculate spikes. Fruit articles, one or two, globular-ovoid, nearly yellow when ripe, covering the small trees on the hillsides.

Tabernæmontana orientalis, R. Br.
A tall shrub, with white fragrant flowers. Carpels of fruit ovoid-falcate, orange coloured.

Alstonia verticillosa, F. v. M.
I only met with this tree in a young state, 6 to 9 feet high, too young to flower.

Parsonsia nesophila, Bail., n.sp.
A very large velvety climber of little or no beauty. Flowers small, yellow.

Loganiaceæ. (Strychnos Family.)

Mitrasacme polymorpha, R. Br.
A small straggling plant found on damp land. Flowers white.

Convolvulaceæ. (Morning Glory Family.)

Ipomœa alata, R. Br. "Winged Stemmed Morning Glory."
I saw no flowers, but from the old foliage and seed capsules, I think it Brown's plant. It is a very large climber, and grows over the shrubs near the beach.

I. paniculata, R. Br. "Panicled Morning Glory."
Found with the last, and, like it, a rampant climber.

I. hederacea, Jacq. "Ground-ivy Morning Glory."
This is a great climber, but met with further from the beach, liking the scrub land. The seeds of this plant even at the present time are used in India as a purgative, under the name of "Kala-dana."

I. angustifolia,, Jacq. "Narrow-leaved Morning Glory."
A pretty twiner with narrow leaves 1 to 3 inches long, often enlarged and toothed at the base.

I. Pes-capræ, Roth. "Goat's-foot Morning Glory."
A prostrate plant found running along the beach sands, the leaves usually two-lobed.

Polymeria ambigua, R. Br.
Stems trailing on the coast sands. Leaves slender, oblong, often mucronate, and at the base cordate.

Evolvulus alsinoides, Linn.

A neat little plant, silky-hairy. Flowers, bright blue, about 3 lines across.

Solanaceæ. (Nightshade Family.)

Solanum viride, R. Br.

A tall shrub, with deep green leaves. Flowers in spreading panicles, blue, with narrow corolla-lobes. Fruit, red, small, and globular.

Physalis minima, Linn., var. *indica*.

Plant erect; leaves irregularly sinnate, lobed, membranous, calyx enlarged after flowering, and acutely angled; on waste places as if introduced.

Scrophularineæ. (Figwort Family.)

Adenosma cœrulea, R. Br.

A coarse troublesome weed, about 2 feet high, with blue flowers.

Vandellia alsinoides, Benth.

A pretty branching plant of wet places.

Buchnera tetragona, R. Br.

An erect plant, the flowers white in four-sided spikes.

B. urticifolia, R. Br.

The radical leaves almost rosulate, usually rough; flowers white; the corolla glabrous outside.

B. ramosissima, R. Br.

The plant more branched than the last, and the corolla pubescent outside. All the plants of this genus are found on damp land.

Bignoniaceæ. (Trumpet-flower Family.)

Tecoma australis, R. Br.

This climber is met with in most parts of Queensland, varying much in size of flowers.

Diplanthera tetraphylla, R. Br.

The trees of this grand tree are only met with here in a stunted form. The flowers, however, seem of a brighter yellow than on the mainland.

Acanthaceæ. (Acanthus or Bear's Breech Family.)

Nelsonia campestris, R. Br.

A prostrate herb, the stems and foliage clothed with soft silky hairs. Found on damp land.

Ruellia acaulis, R. Br.

A low plant, with decumbent stems, from a short stock. Found on the hill-sides.

Asystasia australasica, Bail., n.sp.

A rather showy plant, about 15 or 18 inches high; flowers, pale blue. Found in the scrub under the shade of trees. In flower, June.

Acanthus ilicifolius, Linn. "Holly-leaved Bear's Breech."

Stems, 2 to 5 feet high. Leaves glossy, oblong, the margins often prickly. Found in the salt-water swamps under the mangroves.

Justicia procumbens, Linn.

A common weed in many parts of Australia.

Eranthemum variabile, R. Br.

A most variable, but pretty plant, common to all Queensland scrubs. The large form is the one mostly met with on the island, which is often purple on the underside of the leaf.

Verbenaceæ. (Verbena Family.)

Premna obtusifolia, R. Br.

A tall spreading shrub; leaves almost orbicular; flowers in terminal corymbose panicles, small, white. Drupes, 2 or 3 lines diameter. Found growing near the beach.

P. integrifolia, Linn. var.

Specimens, which may be a variety of this species, were gathered by Mr. E. Cowley two or three years ago.

Clerodendron inerme, R. Br.

A tall shrub, common along the coast, is also met with at about high-water mark. The leaves are mostly ovate-elliptic, on rather long stalks. The flowers, with corolla tube, about 1 inch long; the stamens protruding about 1 inch. Drupe obovoid.

Gmelina macrophylla, Benth.

A small tree, with very large somewhat slate-coloured leaves, often 8 inches long and 5 inches broad. On the main land the leaves at times are 18 inches long and 9 inches broad. The two or four flat glands near the base of the blade very prominent; these are referred to by Baron Mueller in one of his Fragmentas, but are not noticed by Bentham in the Flora Austr.

Avicennia officinalis, Linn. "White Mangrove."

Amongst all the mangrove trees this is at once detected by the breathing processes which arise from its roots. Mr. E. Palmer says that the fruit of this tree is baked or steamed by the natives, in hollows made in the ground, in which they make fires; it is soaked, and afterwards baked in the ashes.

Labiatæ. (Thyme Family.)

Salvia plebeia, R. Br. "Australian Sage."

A weedy plant 2 or 3 feet high, with pale-coloured flowers.

S. coccinea, Linn. "Scarlet-flowered Sage."

A plant 2 or 3 feet high, flowers scarlet; a North American species which has become naturalised in many parts of Queensland.

Anisomeles salvifolia, R. Br.

A plant 3 or 4 feet high; a weed of scrub land; flowers pale-coloured.

Nyctagineæ. (Marvel of Peru Family.)

Boerhaavia diffusa, Linn. "Goitcho," of Cloncurry natives (E. Palmer), Hogweed. Roots eaten by the Boulia aborigines, who call it Witooka (Dr. Roth).

A procumbent weed found all over Australia; often troublesome in cultivation plots. Mr. E. Palmer says that the yam-like roots of this plant when roasted have a pleasant mealy taste, and are very nourishing.

Pisonia aculeata, Linn.

A large straggling plant, armed with recurved prickles, often found near the mangroves, forming an impenetrable mass.

Amarantaceæ. (Amaranth Family.)

Amarantus viridis, Linn.

A common weed.

Trichinium distans, R. Br.

A plant making but a few erect wiry branches; leaves narrow. Flowers in a much interrupted spike, greenish.

Achyranthes aspera, Linn.

A very troublesome weed on scrub land. Perianths reflexed, in long slender terminal spikes.

Aristolochiaceæ. (Birthwort Family.)

Aristolochia indica var. magna, Benth. "Birthwort."

A slender scrub climber.

Piperaceæ. (Pepper Family.)

Piper subpeltatum, Willd. "Large-leaved Pepper-shrub."

A soft wooded plant 4 to 5 feet high, with large orbicular-cordate leaves, spikes of flowers numerous in the axils, of various length.

Laurineæ. (Laurel Family.)

Cassytha filiformis, Linn. "Laurel-dodder."

This wiry leafless climber covers most of the trees and shrubs growing in the open portions of the island.

Proteaceæ. (Grevillea or Silky Oak Family.)

Xylomelum salicinum, A. Cunn. "Wooden Pear."

A small tree with pale foliage; flowers small in spikes. The fruit, obpyriform, opening at length in two woody valves. This tree is seen here and there, but is not plentiful.

Loranthaceæ. (Mistletoe Family.)

Loranthus longiflorus, Desr. "Mistletoe."

This common species is met with growing upon various kinds of trees.

Euphorbiaceæ. (Spurge Family.)

Euphorbia serrulata, Reinw.

E. Mitchelliana, Boiss.

E. pilulifera, Linn.

Small herbs with a milky sap; found amongst the grass.

Bridelia tomentosa, Blume.

A large shrub with ovate elliptical pubescent leaves, and small globular fruits; found on the hill-sides.

Phyllanthus simplex, Retz.

A small wiry plant found on the hillsides.

Petalostigma quadriloculare, F.v.M. "Bitter-bark or Bitter-crab."

A small tree, the bark very bitter.

Croton arnhemicus, Muell. Arg.

A tall shrub, leaves 5 or 7-nerved, capsule globular.

Claoxylon Hillii, Benth.

A tall leafy shrub with large ovate leaves. The open capsules showing the reddish seeds gives a pretty appearance to the plant.

Mallotus philippinensis, Muell. Arg. "Kamala Tree."

A small tree met with, but not plentiful, on the island.

Macaranga tanarius, Muell. Arg. "Tumkullum" of the Moreton Bay blacks.

A small tree with large peltate leaves; found near the beach.

Excœcaria Agallocha, Linn. "Milky Mangrove or Tiger's milk tree."

A common coast tree with a milky sap.

MONOCOTYLEDONS.

Orchideæ. (Orchis Family.)

Sarcochilus phyllorrhizus, F.v.M.

A leafless species which is rather plentiful on scrub trees, adhering to the bark by its broad, thin, flat roots.

Scitamineæ. (Arrowroot Family.)

Curcuma australasica, Hook.

The annual flower stems arising from a fleshy rhizome, bracts of the flower spikes rose-coloured, flowers pale yellow. Found on the hill-sides amongst rocks.

Hæmodoraceæ. (Blood-root Family.)

Hæmodorum coccineum, R.Br. "Blood-root." "On-tho" of the Mitchell natives (E. Palmer).

A very showy, erect plant, with grass-like leaves and a terminal corymbose panicle of red flowers; very showy. Amongst rocks, in more or less damp spots Mr. E. Palmer informs us that on the Mitchell River the natives obtain the fibre from the leaves of this plant with which they make the bags used for straining *Karro** meal.

Amaryllideæ. (Amaryllis Family.)

Curculigo ensifolia, R.Br.

Stem short, rhizome with fibrous roots, leaves grass-like, flower spikes short, at base of leaves.

Dioscorideæ. (Yam Family.)

Dioscorea (?) kumaonensis, Kunth. "Yam."

From the foliage and bulbils. The plants I found growing in the gullies between the hills seem closely allied to the above species, but I found neither flowers or fruit. It seems to be of rather slender growth. The leaves of from three to five lanceolate digitate leaflets, and the stem, petioles, and veins of the leaves more or less hairy.

Liliaceæ. (Lily Family.)

Smilax australis, R.Br. "Australian Sarsaparilla."

A tall, prickly scrub climber; leaves large; flowers in umbels; berries black.

Dracæna angustifolia, Roxb. "Narrow-leaved Dragon-tree."

A small tree, with long narrow leaves and terminal panicles of white narrow flowers. Fruit yellow, more than ½ inch diameter, pulpy inside, containing one to three large seeds.

Dianella cœrulea, Sims. "Blue-berry."

A plant with distichous leaves and blue flowers and berries.

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* *Karro* is the name of the Mitchell blacks for *Dioscorea sativa*.—E. Palmer.

Thysanotus (?) tuberosus, R.Br. "Fringe violet."
The plants seen were very poor specimens.

Tricoryne platyptera, Reichb.
A small, undershrub, with few flattened stems and yellow flowers.

Commelynaceæ.

Commelyna ensifolia, R. Br. "Spiderwort."
A weak, procumbent plant ; differing from the other Australian species in that the spatha is not cordate, and is closed at the base, forming an oblique turbinate inverted cone, open at the top only. Found on damp land.

Floscopa paniculata, Hassk.
Stem weak, about 1 foot high ; leaves, 2 or 3 inches long. Flowers, small, bright blue. On damp land.

Cartonema spicatum, R. Br.
Stems branching at the base ; spikes dense ; outer perianth-segments 5 to 6 lines long, very hairy ; inner ones obovate ; filaments flattened. On damp land. Specimens received from E. Cowley, 1893.

Flagellarieæ. (Flagellaria Family.)

Flagellaria indica, Linn. "Smooth cane."
A smooth, climbing cane ; known by the curl at end of leaf. In the scrubs.

Palmæ. (Palm Family.)

Cocos nucifera, Linn. "Coco-nut."
Probably an introduction.

Nipa fruticans, Wurmb.
Fruits of this plant may frequently be picked up on the beach, but I saw no growing plants.

Pandanaceæ. (Screw Pine Family.)

Pandanus odoratissimus, Linn. f. "Screw Pine."
Near the coast on swampy land.

Cyperaceæ. (Sedge Family.)

Cyperus polystachyus, Rottb.
Seldom much over 1 foot high ; the inflorescence are crowded into a head of spikelets ; involucral bracts, two to four.

Fimbristylis nutans, Vahl.
A slender plant, 6 to 12 inches high ; spikelet solitary, more or less nodding.

F. diphylla, Vahl.
A slender, tufty, perennial ; umbel more or less compound ; involucral bracts, one or two ; exceeding the inflorescence.

F. dichotoma. Vahl.

A densely tufted plant; the lower leaves numerous, flat; involucral bracts, two or three.

Remirea maritima, Aubl.

A common plant on the coast sands, with long running stems forming tufty plants at the joints a few inches high.

Rhynchospora Wallichiana, Kunth.

Stems 1 to 2 feet high; spikes numerous in a dense globular head; involucral bracts spreading, 2 or 3 inches long.

Schœnus sparteus, R. Br.

Stems very wiry, 1 to 3 feet high; the brown leaf-sheaths bearded with white hairs at the orifice.

Gramineæ. (Grass Family.)

Paspalum scrobiculatum, Linn. "Ditch Millet."

A strong tufty, rather hard, grass.

P. distichum var. littorale. "Seaside Millet."

A creeping coast grass.

Panicum sanguinale, Linn. "Summer Grass."

A large decumbent annual.

P. semialatum, R. Br. "Cockatoo Grass."

A tall-stemmed grass, panicle of from two to five long, erect, branches.

P. argenteum, R. Br.

A softly hairy grass. The spikelets particularly silvery.

P. colonum, Linn. A small form.

Somewhat decumbent. Panicle of from eight to ten one-sided, distant short spikes.

P. indicum, Linn.

A wiry, erect grass; panicle spikelike. Found on damp land.

P. effusum, R. Br. A tall form.

A tall branching grass, 3 to 4 feet high, with large spreading panicles.

Oplismenus compositus, Beauv.

A hairy, spreading grass, commonly met with in scrubs.

Setaria macrostachya, H. B. and K.

A tall, leafy grass, of scrub lands, mostly found on the border of scrubs.

Cenchrus elymoides, F. v.M. "Scrub Burr-grass."

A tall, coarse, erect grass; spikes often 6 inches long.

Thuarea sarmentosa, Pers.

A creeping grass, met with upon the coast sands. The erect stems short.

Arundinella nepalensis, Trin.
A tall, harsh grass of erect growth, met with on the hills.

Pollinia irritans, Benth.
A grass of 2 or 3 feet in height, with several spikes in the head.

Rottboellia formosa, R. Br.
Stems from 6 to above 12 inches high, with more or less hairy leaves; the cylindrical spikes very fragile; the articles with purplish hairs. Very plentiful.

R. rariflora, Bail.
A procumbent, weak, but very troublesome, spear grass, too plentiful on the island.

Ischæmum fragile, R. Br.
A slender grass with narrow leaves; spike single, rigid, on a long peduncle.

Heteropogon contortus, Rœm. et Schult. "Bunch spear grass."
A troublesome spear grass, 2 or 3 feet high. Awns often 2 inches long and very much twisted; the heads of a number of stems often adhering together and forming large dark-coloured masses.

H. insignis, Thu. "The tall spear grass."
Spikes often 5 or 6 inches long without the awns, which are about the same length.

Andropogon exaltatus, R. Br.
Stems 1 foot or more high; leaves very narrow, sometimes subulate from the sheath. Nodes glabrous; spikes two or three together, densely hairy.

A. lanatus, R. Br.
Leaves usually flat but narrow; spikes densely woolly-hairy.

Chrysopogon parviflorus, Benth. "Scented golden beard."
A large tufty grass, the inflorescence strongly scented. Specimens received from E. Cowley, 1893.

Eriachne squarrosa, R. Br.
Stems about 2 feet high; nodes with long silky hairs; panicle dense; outer glumes hispid; awns about 1 inch long.

E. ciliata, R. Br.
A pretty grass usually under 1 foot high, often only a few inches; leaves hirsute, with spreading hairs; spikelets few. On hill-sides.

Cynodon dactylon, Pers. "Common couch."
Met with on the well-trodden ground.

Chloris barbata, Sw. var. "Bearded Star-grass."
Plant, 2 to 4 ft. high; the spikes numerous in the head, dark, and very hairy.

Eleusine ægyptiaca, Pers. "Small Crow-foot Grass."

A very common grass upon the island, usually on the flat land. Spikes, 3 to 5 in a spreading head. Dr. W. E. Roth gives an interesting account of the mode adopted by the natives at Boulia in preparing "damper" from the seeds of this grass, called by them "ya-ra-ka." "Ethnological Studies among the N.W. Central Aborigines."

Triraphis mollis, R. Br.

Panicle narrow, dense, 4 to 6 in. long, having a soft appearance.

Eragrostis Brownii, Nees. "Love Grass."

A very variable grass, met with in most parts of Queensland.

Ectrosia leporina, R. Br. "Hare's Tail Grass."

A glabrous grass of 1 or 2 ft.; panicle dense, soft-looking, and 3 to 6 in. long.

ACOTYLEDONS OR CRYPTOGAMS.

The small number of cryptogamous plants which I am enabled to record as having been observed on Thursday Island may in some measure be accounted for by my visit to the island having been made at the dry season of the year, and from the fact also that what is considered there as the wet season had this year passed over without the usual quantity of rain. I, however, do not think from what I saw of the vegetation that this particular island is one likely to furnish any great variety of these plants. On some of the other islands, having a better water supply and larger area of scrub, these plants are likely to be found more or less abundant. All I can record at present are—

Filices.

Lygodium japonicum, Sw.

Polypodium scandens, Forst.

Notholæna fragilis, Hook.

N. Prenticei, Luerssn.

Fungi.

Polyporus fruticum, Berk.

On the twigs of trees.

Polystictus cinnabarinus, Fries.

On dead wood. Dr. Roth informs me that this common red fungus is worn as a forehead ornament by the natives of Keppel Island.

Uromyces fusisporus,* Cke. and Mass.

Phyllosticta Acaciæ,* Cke.

Both on the phyllodes of acacias.

* Not previously recorded for Queensland; determined by Dr. M. C. Cooke.

No. 2.—PLANTS OF THE RABBIT-INFESTED COUNTRY, BULLOO RIVER, S.Q.

By J. F. Bailey.

(Read Friday, January 7, 1898.)

Early in November I accompanied Mr. C. J. Pound, the Government Bacteriologist of Queensland, on a trip to the Bulloo River district, where he was carrying out experiments for the destruction of rabbits by means of the chicken-cholera microbes. This offered a good opportunity of making a botanical examination of the locality. The season was not one that could be called favourable for the purpose, as little or no rain had fallen for the previous twelve months. On our arrival at Thargomindah, the post-town of the district, we were detained for some days on account of heavy rains. Our first camp was at Dilltoppa, about 45 miles from Thargomindah, and on arrival here we found that the rain had given rapid spring to the herbage, so that we were able to form some idea of the plants growing about. From here we worked our way to Koopa and Cooliata Sandhills, but found little change in the vegetation. Our time being limited, and the difficulty of travelling being increased by the rains, we were prevented from visiting the part of the Grey Range running through the district, where it was hoped the principal novelties would be obtained, as little or nothing is known of the plants of that locality.

The following list cannot be taken as representing the flora of the district; but will give some idea of those plants which were able to withstand the severity of the climate of those parts, and produce food when all else is parched up. It was impossible to identify those which had sprung up owing to the recent rains, and causing the country to look so green, as they were, of course, in too young a state.

I am indebted to Mr. Pound for the photographs which accompany this paper.

CAPPARIDEÆ.

Capparis Shanesiana, F.v.M., and *Capparis nobilis*, F.v.M.—Fine specimens of these handsome flowering small trees were met with, and were a pleasant sight after the dreary stretches of mulga, gidya, and coolibar.

PITTOSPOREÆ.

Pittosporum phyllyræoides, DC., in young fruit was noticed growing near a dam.

FRANKENIACEÆ.

Two varieties of *Frankenia pauciflora*, DC., viz., *serpyllifolia* and *thymoides* were growing in sand on the edge of a large lagoon. Both have pretty pink flowers, but are of quite different habits, the former lying flat on the ground, while the other is erect.

PORTULACEÆ.

Portulaca oleracea, Linn.—A large-flowering variety of this common garden weed was very abundant. The natives use the seed and also the whole plant for food, and at times even bushmen use it in the latter form.

MALVACEÆ.

Abutilon Fraseri, Hook., with its large yellow flowers, looked very gay among the smaller kinds of salt-bush.

MELIACEÆ.

Owenia acidula, F.v.M. The Emu Apple or Grewie of the natives. Clumps of these trees in both flower and fruit were occasionally seen. They form very handsome trees, having dense dome-like heads, and branch out about 7 feet from the ground. Probably this is due to their lower branches being cropped by stock, and as no young plants were seen they evidently eat these also. Plate XXII.

SAPINDACEÆ.

Atalaya hemiglauca, F.v.M. The "White Wood," is very abundant throughout the district, and according to report is often cut down, in times of drought, as food for cattle, but is said not to be over-relished by them. It was occasionally seen in flower, but most of the trees were covered with the curious winged fruit of the genus. Plate XXIII.

Dodonæa attenuata, A. Cunn. One of the so-called hop-bushes was growing in great profusion on the sandy ridges at Dilltoppa, and the sandhills at Koopa and Cooliatta. The rabbits seem very fond of the bark, for we found it stripped to some considerable distance from the ground, with the result that most of the trees so treated die.

LEGUMINOSÆ.

Psoralea patens, Lindl. Small plants of these were seen. According to E. Palmer, the natives obtain a fibre from the stems.

Two Cassias were met with rather frequently, viz.:—

Cassia eremophila, A. Cunn., with long narrow leaves and brown pods, and *Cassia phyllodinea*, R.Br., with silvery leaves and bright yellow flowers, the perfume of the latter, when fresh, reminding one of the heliotrope of our gardens.

Acacias.—The principal species of this genus in these parts is *A. aneura*, F.v.M., the Mulga, two forms of which were seen, one having very narrow leaves. They have been cut down for fodder, and also eaten down very extensively throughout the district. Plate XXIV.

The Gidya, *Acacia homalophylla*, A. Cunn., is the largest Acacia to be met with. The unpleasant odour from the foliage of this tree, especially after rain, is said to often cause a kind of fever in stockmen and others. I did not notice that stock ate the leaves, but was told that they sometimes eat the young pods. Plate XXIII.

Acacia salicina, var. *varians*, was noticed growing near water.

On the banks of the river, and its billabongs, was growing *Acacia stenophylla*, A. Cunn., the Dalby Myall, with long drooping leaves and pods, the latter moniliform. This forms a very graceful shrub.

Other Acacias were *A. harpophylla*, F.v.M., the Brigalow, with long, boomerang-shaped, silvery leaves—Plate XXI; *A. Oswaldi*, F.v.M.; *A. decora*, Reichb., with its light-green foliage and thin pods, making a most ornamental shrub; and *A. tetragonophylla*, F.v.M., a straggling shrub with globular heads of yellow flowers, and clumps of short needle-like leaves.

MYRTACEÆ.

As in most parts of Western Queensland, the commonest eucalypt is *E. microtheca*, F.v.M., the "Coolibar." Plate XXI.

The largest eucalypt of the district is *Eucalyptus rostrata*, Sch., which is found by the side of the river and its billabongs. The trees were laden with flowers, and those on the long drooping branches produced a most attractive sight. At Koopa, most of the trees had large nests of the hawk of the district. Another large eucalypt was *E. ochrophloia*, F.v.M., the "Yapunyah." The base of the stem is black, and the upper part, as well as the branches, reddish pink. The leaf is large and thick.

The only other species of the genus noticed was *E. corymbosa*, Sm. Bloodwood.

Melaleuca ericifolia, Sm. A variety of this species was met with.

FICOIDEÆ.

Masses of *Mesembryanthemum æquilaterale*, Haw., the "pig's-face" of our gardens, were growing on the sandy ridges at Dilltoppa.

UMBELLIFERÆ.

On the sandhills at Koopa were noticed the dried stems of *Trachymene cyanopetala*, Benth., with seeds attached. This plant is not eaten by rabbits or stock.

COMPOSITÆ.

Among the plants of this order were :

Gnephosis cyathopappa, Benth., a rigid slender corymbosely-branched plant of a few inches high with bronzy coloured globular heads of flowers. Found on the Mulga ridges.

Centipeda orbicularis, F.v.M., var. *lanuginosa*.

Helichrysum apiculatum, DC., with very bright yellow flowers and exceedingly woolly stems, and

Minuria integerrima, Benth.

OLEACEÆ.

Jasminum lineare, R. Br. The bark of this plant was much eaten by rabbits on the sandhills at Koopa.

GENTIANEÆ.

Erythræa australis, R. Br., the bushman's headache cure, with its pretty pink flowers was very common.

CONVOLVULACEÆ.

That pretty blue-flowered Evolvulus—*E. alsinoides*, var. *sericeus*.

SOLANACEÆ.

The two Solanums common in the district are *S. chenopodium*, F.v.M., and *S. esuriale*, Lindl. The fruit of the latter is used by the natives.

Nicotiana suaveolens, Lehm. The native tobacco, was growing very abundantly at Cooliata.

SCROPHULARINEÆ.

In the sand at the side of a large dried-up lagoon was a dense growth of *Mimulus prostratus*, Benth. So numerous were the blue flowers on this little plant that from a distance it gave the appearance of water.

Another species of the genus *M. gracilis*, R. Br., was also met with, but is by no means as pretty as the last-mentioned.

MYOPORINEÆ.

The Eremophilas are well represented, there being *E. bignoniæflora*, F.v.M., called by the natives "Quirramurrah." Cattle seem fond of this species, and the rabbits which were confined for experimental purposes preferred the leaves and young shoots to any other plant. The plant when bruised or burned has a very disagreeable odour.

E. longifolia, F.v.M., with black shiny fruits.

E. Mitchelli, Benth. The bark of which is much eaten by rabbits.

E. maculata, F.v.M., with pretty red flowers dotted with dark spots; and

E. polyclada, F.v.M., which has somewhat the habit of the "Lignum" (*Muehlenbeckia Cunninghamii*, F.v.M.), and is often confounded by bushmen with that plant. This has pretty white open flowers.

Myoporum deserti, A. Cunn, another plant of this order was noticed here and there.

LABIATÆ.

Mentha australis, R. Br., grows very rank near water, some of the stems attaining a height of 8 feet, and giving to the air a sweet perfume.

The only other plant of this order noticed was *Teucrium racemosum*, R. Br.

NYCTAGINEÆ.

In all sandy places *Boerhaavia diffusa*, Linn., was growing. In other places this is said to be eaten by stock, but we did not find this to be the case. Neither did the rabbits seem to touch it.

AMARANTACEÆ.

The common garden weed, *Alternanthera nodiflora*, R. Br., with its little round head of white flowers, was continually met with.

CHENOPODIACEÆ.

Fortunately for the stock of the district, there is a good variety of the so called cotton and salt bushes, which are useful for helping stock to digest some of the harsh foliage of shrubs, such as mulga, white-wood, &c. Nearly all the year round these plants supply food, for on account of the small rainfall grasses are very scarce. Rabbits are very fond of all kinds of these plants, and have destroyed immense numbers of them by ringbarking the stems and burrowing under them.

Stock are very fond of the commonest cotton-bush in these parts, —viz., *Kochia aphylla*, R. Br., and we found these so eaten down that it was impossible to get good specimens. Plate XXV.

Other Kochias noticed were *K. villosa*, Lindl., and *K. brevifolia*, R. Br., but neither was growing as large as *K. aphylla*.

Fine specimens of the Old-man Saltbush *Atriplex nummularia*, Lindl., also *A. fissivalve*, F.v.M.; *A. vesicaria*, Heward; *A. leptocarpa*, F.v.M.; and the small-growing *A. Muelleri*, Benth., Plate XX, were in evidence.

The Bluebush, *Chenopodium auricomum*, Lindl., furnishes good fodder, and is eagerly sought after by cattle. Plate XX.

Fine bushes of *Rhagodia spinescens*, R. Br., were growing about Dilltoppa, Koopa, and Cooliata. We found that the rabbits ringbarked the stems and burrowed under these plants more than any other, and by so doing they threaten to eradicate all the useful fodder-plants from the above-mentioned places. Other species of this genus met with were *R. nutans*, R. Br., and *R. parabolica*, R. Br., the latter having a most disagreeable taste and odour.

Other plants of this order noticed were *Salsola kali*, Linn., and its variety *strobilifera*, and that most disagreeable plant *Sclerolæna bicornis* (Lindl.), the fruits of which are furnished with strong spines.

POLYGONACEÆ.

The principal plant of the river-side is the "Lignum" *Muehlenbeckia Cunninghamii*, F.v.M. This forms dense masses and is used as food and shelter by the rabbits. Cattle and horses are also fond of the plant and eat most of the leaves, so that bare stems are only seen, but these with the advent of a shower of rain again burst into leaf. (Plates XXIV and XXV.)

Another plant of this order, viz., *Polygonum plebeium*, R.Br., grows in similar situations.

PROTEACEÆ.

One of the most attractive shrubs of the district is *Hakea leucoptera*, R.Br., one of the needle-bushes. The growth is very even and dense, and branches right to the ground. *Hakea lorea*, R.Br., also grows in the district, and forms a graceful tree with cord-like leaves, which on some trees are forked.

Splendid trees of the Beef-wood, *Grevillea striata*, R. Br., grow in these parts. Most of them were in full flower. The gum, mixed with the ashes of species of Acacia, probably *A. salicina*, var. *varians*, is used by the natives for affixing spear-heads, &c. (Plate XXII.)

LORANTHACEÆ.

A *Loranthus*, viz., *L. Quandang*, Lindl., with bright red flowers, was growing in large masses on the whitewood (*Atalaya hemiglauca*). (Plate XXIII.)

SANTALACEÆ.

Santalum lanceolatum, R.Br., grows throughout the district, but is not at all scented.

EUPHORBIACEÆ.

Everywhere was growing that widely-distributed *Euphorbia*, *E. Drummondi*, Boiss. The natives and also stockmen have great faith in the milky juice of this plant as a healing agent for sores, &c.

Plenty of another *Euphorbia*, *E. eremophila*, A. Cunn., grows also in these parts. Stock or rabbits eat neither of these species.

AMARYLLIDEÆ.

Large patches of *Crinum angustifolium* were just commencing to bloom at the time of our departure. The flowers are very showy and sweet-scented, but the latter is rather overpowering when in quantity. The bulbs are about a foot below the surface of the soil, and are embedded in cement-like clay, making it almost an impossibility to obtain them without the aid of a spade or similar implement.

CYPERACEÆ.

The commonest sedge met with was *Cyperus esculentus*, Linn., and is eaten by stock. It grows like the common "Nut-grass" (*C. rotundus*, Linn.).

Others of the order were seen, but in too young a state for identification.

GRAMINEÆ.

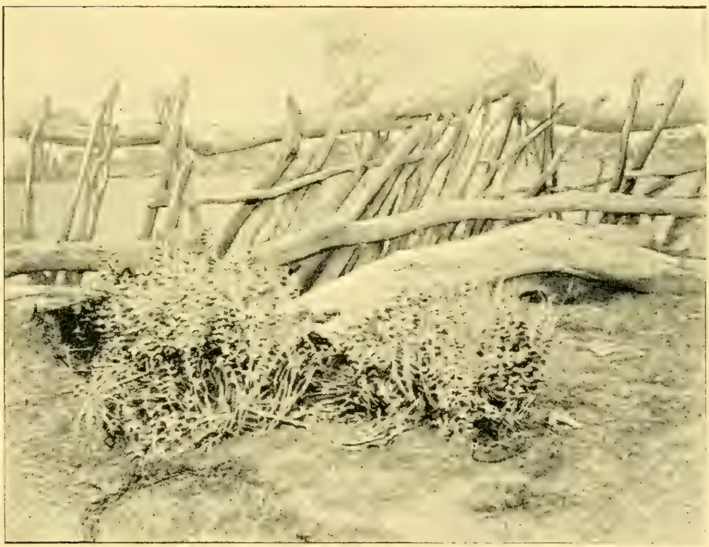
Very few grasses were to be seen on our arrival in the district, but before the end of our three weeks' stay I was able to collect specimens of *Panicum flavidum*, Retz ; *Pappophorum nigricans*, R.Br. ; *Eragrostis chætophylla*, Steud ; *Triraphis mollis*, R.Br. ; *Sporobolus Lindleyi*, Benth. ; and *S. Benthami*, Bail. This latter has long running stems, at the nodes of which young plants are produced.

The only plant which seemed to grow in the "claypans" was the Cane-grass, *Leptochloa subdigitata*, Trin. This grass was to all appearance dead, but after a shower of rain all the dead-like stems produced tufts of green shoots from the nodes. These "claypans" are composed of hard, white, cement-like soil, and on a hot day are very trying to the eyes and feet. No doubt there were many others of this order, but they were in too young a state for determination.

MARSILEACEÆ.

The Nardoo, *Marsilea Drummondii*, A. Braun, was growing in great profusion on the sides of the river and its billabongs and also waterholes.

ATRIPLEX MUELLERI, BENTH.



CHENOPODIUM AURICOMUM, LINDL.

Plants of the Rabbit Infested Country, S.W. Queensland.

J. F. BAILEY.

EUCALYPTUS MICROTHECA, F. v. M.

ACACIA HARPOPHYLLA, F. v. M.

Plants of the Rabbit Infested Country, S.W. Queensland.

J. F. BAILEY.

GREVILLEA STRIATA, R. BR.

OWENIA ACIDULA, F. v. M.

Plants of the Rabbit Infested Country, S.W. Queensland.

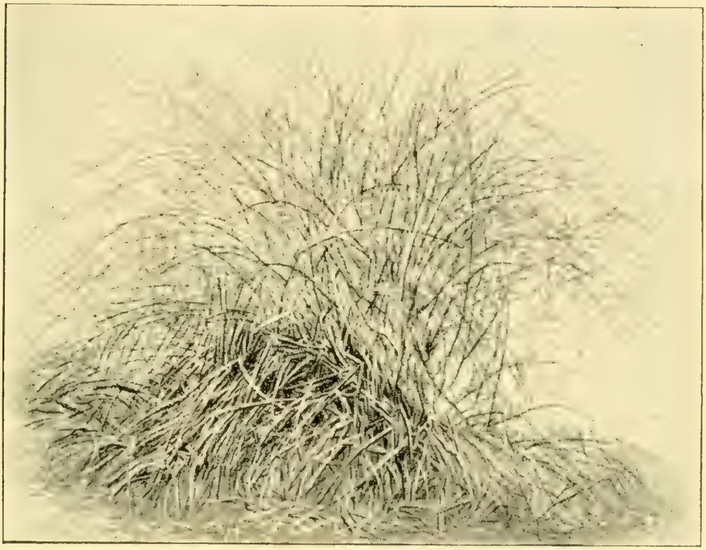
J. F. BAILEY.

ATALAYA HEMIGLAUCA, F. v. M. AND LORANTHUS QUANDANG, LINDL.

ACACIA HOMALOPHYLLA, A. CUNN.

Plants of the Rabbit Infested Country, S.W. Queensland.

J. F. BAILEY.

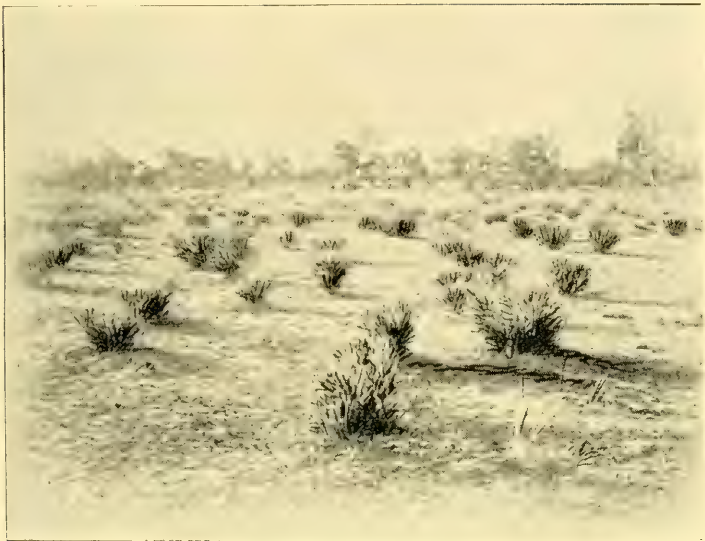


MUEHLENBECKIA CUNNINGHAMII F. v. M.

ACACIA ANCURA, F. v. M.

Plants of the Rabbit Infested Country, S.W. Queensland.

J. F. BAILEY.



KOCHIA APHYLLA, R. BR.

MUEHLENBECKIA CUNNINGHAMII, F. v. M.

Plants of the Rabbit Infested Country, S.W. Queensland.

J. F. BAILEY.

No. 3.—NOTES ON THE PLANTS INDIGENOUS TO THE NORTH-WEST PORTION OF THE COLONY OF VICTORIA.

By St. Eloy D'Alton.

(*Read Tuesday, January* 11, 1898.)

[*Abstract.*]

The district to which this paper refers lies between the river Wimmera and the South Australian Border, in the extreme north-west corner of the colony, indicated on the map as the counties of Lowan and Weeah. With the exception of the river Wimmera, this territory is totally devoid of anything like a river-bed or water-course, with perhaps one or two exceptions, where comparatively short streams, flowing only in very wet winters for a few months, empty themselves either into run-away holes, or shallow depressions, which for a time may be regarded as swamps, but which for several years in succession might have been dry enough as to be put under cultivation. The river Wimmera is of the usual typical Australian sort—a chain of water-holes. In wet winters, when these holes are full, the water flows into Lake Hindmarsh; from thence the course of the creek may be traced to Lake Albacutya, Wonga Lake, Pine Plains, and some miles to the north of Pine Plains, where it loses itself amongst the sand-hills of that region, which forms a belt before reaching the river Murray, from the south. The district referred to is traversed from east to west with belts of fertile, undulating country, separated by strips of poor, sandy scrub, or thick mallee, varying in width from 12 to 60 miles, the line of demarkation between the good and the bad land being sharply defined. In the south-east corner of the district Mount Arapiles rises, a conspicuous object, abruptly out of the plain, to a height of about 1,000 feet, its eastern side presenting a bold escarpment of red sandstone, several hundred feet high. Standing about half a mile away is a rock, which from its shape is called the Mitre rock. The summit of this rock cannot be reached on account of its precipitous nature, and in its clefts and crannies grow several species of plants, which will be alluded to further on. The mount can be ascended in many places, particularly from the west side, where there is a deep gorge through which in wet seasons a small stream trickles. In the precipitous eastern face of the mount are two or three very steep, rocky clefts or gorges, and it is in such places that the rarest plants are to be found. This is the

only eminence that has any claim to be called a mount in the whole north-west territory. Low ranges of sand-hills, covered with scrub and porcupine grass, are the nearest approach to hills, and these for the most part trend from south-east to north-west. One of those strips of useless country, a spur of the South Australian 90-mile desert, which extends in an unbroken line due east to the Wimmera River, is called the "Little Desert," as a distinction from the Great Desert, which is another spur running nearly parallel to it some miles further north. One of those scrubby ranges of low hills above referred to nearly connects these two strips about half way between the Wimmera and the South Australian Border, and this is known as the Lawloit Range. Red sandstone and a conglomerate rock of iron-stone nodules embedded in sandstone abounds on those ranges. In many places extensive tracts of limestone exist, usually in conjunction with iron-stone. Close to Mount Arapiles are several large salt lakes, and in the northern parts large quantities of gypsum exist, either as a white dry powder piled up in hillocks, or as a solid, in the form of transparent flakes. The swamps may be only regarded as such in wet seasons, and are nearly always dry; but within the last six or seven years most of them got full to overflowing, and are now nearly all dry again. What is regarded as the best agricultural land consists of the so-called crab-holey plains, the soil being of a very clayey nature, thrown up into low mounds. the depressions between being usually full of water in the winter time, and of low loamy rises, with here and there a few isolated sand-dunes covered with cypress pines and scrub. Approaching the desert country, the soil is much of the same clayey nature; but instead of being comparatively open country, is for the most part thickly clothed with mallee scrub, composed of various species of Eucalyptus, as well as other genera, such as *Dodonæa*, &c. The farmers have taken possession of this fringe, and nearly the whole of it has been rolled down and put under crop. As we get further in, the soil changes for the worst, till at length we enter the desert proper, which has already been described. Such is a brief description of the district to which this paper alludes, and which is meant to convey to the reader an idea of the nature of the various soils in which the plants flourish, and the conditions under which they exist.

Taking the belt of good land first, we find that on the crab-holey plains many plants exist which are not to be found anywhere else, namely, *Swainsona procumbens* and *S. phacoides* side by side with the yellow-blossomed *Zygophyllum glaucescens*, *Sida corrugata*, *Ptilotus exaltatus*, *Euphorbia Drummondii*, *Kochia villosa*, *Kochia microphylla*, *Atriplex halimoides*, *A. semibaccatum*, *Bassia bicornis*, *Mimulus gracilis*, may be found, some on the hardest and driest patches and others, particularly *Mimulus*

gracilis, where the water lies the longest. *Pimelea glauca* is very plentiful on some or most of the plains; also *Eryngium rostratum*, but which, owing to the avidity with which sheep and cattle devour it, is fast disappearing. The Composite family is largely represented by several species of *Brachycome*, particularly *B. pachyptera*, and by the following:—*Minuria leptophylla*, *Calotis scabiosifolia*, *C. hispidula*, *Myriocephalus rhizocephalus*, *Craspedia globosa* (rare), *C. chrysantha*, *Eclipta platyglossa*, *Helipterum Dimorpholepis*, *Goodenia heteromera*, *Teucrium racemosum*, and a particularly bad weed, *Helipterum corymbiflorum*, which has taken possession of whole tracts previously cultivated. On some of the drier rises we are sure to find the lowly *Gnaphaloides uliginosum*, also *Podolepis canescens* in conjunction with its more widely distributed relative *P. rugata*. *Angianthus strictus* is another small plant which prefers the dry hard rises, and where the Bursaria bushes abound, may be found growing amongst them, *Ixiolaena tomentosa* and *Helipterum anthemoides*, *Comesperma ericinum*, *Stenopetalum velutinum*, *Chenopodium nitrariaceum*, *Haloragis odontocarpa* and *Chenopodium microphyllum*. Such plants as *Helipterum pygmaeum*, *Toxanthus Muelleri*, *T. perpusillus*, occur on the loamier soils. The grasses for the most part are represented by *Danthonia penicillata*, *Agrostis Solandri*, *Bromus arenarius*, and *Poa Fordeana*. The only timber trees prevalent on these plains are the Bulloak (*Casuarina glauca*) and a box (*Eucalyptus largiflorens*.) A species or variety of *Casuarina*, of low growth, possessed with a comparatively smooth bark and long flexuous stems, occur in the stiffest soils at rare intervals. The fruits differ materially from those of *C. glauca* and *C. quadrivalvis*. Specimens sent to the late Baron von Mueller could not be identified by him, and a doubt still exists as to whether it is a variety or a separate species. On the loamy rises and lighter soils occur *Menkea australis* in conjunction with plants extending to other parts of the colony, also *Lappula concava*. *Calocephalus Drummondi*, and *Quinettia Urvillei*, plants hitherto thought to be confined to West Australia were identified by Baron von Mueller from specimens gathered in this locality by the writer. On the drier soils we find the Bulloak still the prevailing timber tree, never much more than 18 inches in girth and 50 feet high, associated with a smooth-barked variety of *Eucalyptus leucoxylon*, termed Blue gum by the settlers. In sheltered spots may be found small trees of the sweet Quandong, *Santalum persicarium*, also *Hakea leucoptera*. These are, however, becoming rare, in consequence of the land being put under cultivation. Amongst the plants found on the scrubby rises may be found at rare intervals the small purple-rayed composite *Calotis cuneifolia*. Two shrubby species of Aster occur, but are restricted to separate and distinct areas, namely, *A. pimeleoides* and *A. decurrens*; the former a

rather attractive plant, with large white-rayed flowers, the latter possessing white flowers of small size, and exuding a glutinous secretion from both stems and leaves. In the open glades occur large patches of *Leptorrhynchus*, *Waitzia*, and at rarer intervals *Helipterum floribundum*, also the little yellow-flowered *H. Jessenii*. *H. moschatun* is also partial to such localities, but at still rarer intervals. *Elachanthus pusillus* is another small annual composite peculiar to some loamy soils, generally growing in patches. *Cassinia arcuata* occurs as a tall shrub in a few places, but is fast dying out. As we get nearer to the desert country, the scrub thickens, and mallee scrub proper is entered. The soil for the most part still retains its clayey nature, resting on a stratum of limestone gravel, with an occasional pine rise to break the monotony. Deep depressions are numerous, and these generally terminate in a run-away hole. The land being suitable for wheat-growing, is now, nearly all, brought under cultivation by means of the mallee roller and stump-jump plough. Here may be found some of the most typical plants of this region, such as *Myoporum platycarpum*, a small tree, and, at rarer intervals, *M. deserti*, a bushy shrub. *Eriostemon pungens*, and the pink flowered *E. difformis*, *Bertya oleifolia*, *Dodonæa bursarifolia*, *Cassia eremophila*, *Acacia spinescens*, *A. rigens*, *A. calamifolia*, *A. acinacea*, *A. montana*, *A. hakeoides*, *A. salicina*, *A. trineura* (a species with scented wood), *A. Oswaldi*, near Lake Hindmarsh, *A. brachybotrya* on the sandy rises; a species regarded by Baron von Mueller as a variety of *A. montana*, described by Mr. Reader, a local botanist, as *A. glanduligicarpa*, and *A. sclerophylla*. Another species discovered by the writer has yet to be identified. The late Baron von Mueller regarded it as a distinct species, but deferred naming it until fruits were forthcoming, which, unfortunately, could not be procured in time. Mr. Luehmann considers it to be a variety of *A. lineata* (*A. runciformis* of the Census), or of *A. montana*. The Myrtaceous order is represented by *Eucalyptus gracilis*, *E. uncinata*, *E. incrassata*, *E. oleosa*, and *E. Behriana*, all passing under the general designation of Mallee scrub. The last-named, being of a larger growth than the others, is locally known as the Bull Mallee. Varieties of *E. gracilis* and *E. incrassata* have been noticed bearing pink or scarlet flowers. *Choretrum chrysanthum* is a bushy shrub sparsely distributed throughout the district, rendered conspicuous amongst the scrub by the peculiar hue of its leafless branches, either a pale green, or sometimes an almost golden yellow, making a striking contrast with the sombre-hued foliage of the scrub with which it is associated. It may not be generally known that this plant, particularly the young shoots, possess an acidity which is very acceptable to the traveller who may happen to run short of water. Another species having the same properties, *C. glomeratum*, is a straggling shrub

of rarer occurrence. The desert cherry, *Exocarpus spartea*, may be found either singly or in patches of several acres distributed throughout the mallee fringe, also rendered conspicuous by its peculiar-hued hair-like branches, a yellowish, and more often a brownish-green. Here also occur *Pimelea microcephala* associated with *Helichrysum decurrens* and *Aster tubuliflorus*. The composite, *Erechtites prenanthoides*, closely related to the Senecios, extends to this part of the colony, and is fairly common where the scrub has been burnt. The order *Goodeniaceae* is represented by five genera, and with the exception of a few by all the species enumerated for the colony. The genus *Goodenia* is particularly plentiful, and most of the species abound. *G. varia* occurs sometimes as a trailer or partial climber amongst other shrubs, but generally as a procumbent semi-shrub. *G. pusilliflora*, a small annual species, hitherto overlooked as extending to this part of the colony, is rare on the more open dry patches, also *G. gracilis* in wet places in conjunction with *G. heteromera*. Some peculiar forms of *G. pinnatifida* occur, differing in appearance from the normal species, and two varieties of *G. geniculata*, the one with large flowers and tomentose leaves, and the other with smaller flowers and altogether a smaller plant, may be found on the sandier patches. *Logania linifolia* is rather uncommon, and prefers sheltered spots. At rare intervals, isolated plants of *Lycium australe* occur, and where the scrub had been burnt in recent years *Solanum simile* grows luxuriantly. *S. esuriale* is a small species met with in swampy places, or land liable to periodical inundations. The two species of *Halgania* recorded from Victoria are both fairly plentiful on the light soils. Some fine bushes of *H. lavandulacea* occur not far from Nhill on stiff clay soil, while *H. cyanea* grows by the road-side, in more sandy situations. *H. lavandulacea* makes a fine show when in bloom, the flowers being of a deep blue colour, and the foliage dark shining green. It is, however, subject to a kind of blight, which blackens the stems and leaves; an exudation from the leaves renders it a difficult plant to press properly. Both these species are disappearing rapidly, under the advance of farming operations, and in a few years there will be none left in this district. *Eriostemon sediflorus*, a small shrub with canary yellow blossoms, appearing early in the spring, and densely clothed with pretty foliage, also prefers fairly good soils, unlike its relative *E. stenophyllus*, which delights in pure sand. *E. capitatus* is rare, and occurs only, to the writer's knowledge, in the scrub not far from Nhill. The natural order, *Labiatae*, is represented by two forms of *Westringia rigida*, the one low and rigid, producing white flowers garnished with a few purple spots in the throat, the other taller, of a more lax growth, and producing purple or lavender-coloured flowers; also by two species of *Prostanthera*, *P. coccinea*,

and *P. chlorantha*. *P. coccinea* is fairly common as a small shrub, putting forth showy scarlet blossoms; and the other of somewhat similar growth, but producing flowers of a peculiar greenish colour. Both these species are likely to disappear under the united attacks of sheep and rabbits, as, notwithstanding the strong aroma emitted by the leaves, they seem to be relished by those animals. *Teucrium sessiliflorum* is a species found only in the northern areas on loamy soils. In a few localities may be found that elegant little plant, *Eremophila gibbosifolia*, and on some heavier soils, *E. Brownii*, as a low shrub. *E. longifolia* occurs as a small tree, of pleasing appearance. Of the *Styphelias* we have *S. depressa*, hitherto recorded in the "Census of Australian Plants" as inhabiting West and South Australia only. It occurs as a low, very much branched shrub, of the sandier soils. In the month of October, the plant produces large crops of berries, about the size of small peas, which are eagerly sought for by the settlers for the purpose of jam or jelly making. The jelly made from the fruit, is well flavoured, and of a rich claret colour, although when freshly gathered the fruit has a peculiar heavy, rather musky, odour. The species is gradually dying out, as in gathering the fruit the whole bush is generally pulled up as the speediest method of getting at them. The climbers are represented by *Clematis microphylla* and *Billardiera cymosa*, both of which have a wide range. The usual parasites of the genus *Cassytha* are prevalent everywhere in the scrub. As we advance further in from the edge of the mallee fringe, the taller scrub gives place to those of a lower growth, and to stunted forms of those already enumerated; the soil gets poorer in quality, so as to be worthless for cultivation. On the sandhills, under the shade of the cypress pines early in spring, large crops of such crucifers as *Erysimum lasiocarpum* and *E. curvipes* abound, besides others common to the whole colony. Amongst the scrub may be found *Ionidium* (*Hybanthus*) *floribundum*, producing early in spring, profusions of pretty blue and yellow violet-like blossoms. At very rare intervals an almost pure white variety occurs. About the same time, perhaps a little later, specimens of *Boronia clavellifolia* may be gathered. This is particularly abundant in one locality of the Little Desert towards its south-eastern extremity. A variety of *B. polygalifolia* is rare in same locality, both flowers and leaves, which are trifoliate, being smaller than the normal species which inhabits the Grampians valleys. *B. coerulescens* is more or less common on all sandy soils, the flowers ranging in colour from pure white through all the shades of mauve, violet and pink. Of the same order we have *Zieria veronicea* occurring rather sparsely in the Little Desert, a small plant with pale pink blossoms and smelling of Balm. On the gravelly rises in a few localities specimens of *Lasiopetalum Behrii* may be

gathered in conjunction with its more frequent relative *L. Baueri*. *Didymotheca pleiococca* is partial to sandy flats, but is no where very common. When done flowering the plant turns yellow or reddish-yellow, and is easily distinguished amongst the scrub. The order *Leguminosæ* is largely represented by the *genera Daviesia*, *Phyllota*, *Pultenaea*, *Dillwynia*, *Acacia*, *Kennedya*, and *Aotus*. Of these, a few are restricted to this district. *Daviesia pectinata*, an extremely rigid, thorny species is partial to hard, gravelly, soil, and *Phyllota pleurandroides* is a small shrub found in all the desert country. Of the *Pultenæas*, *P. laxiflora* and *P. tenuifolia* have the widest range, the latter occurs in two varieties, one found only in a particular part of the Little Desert growing to a height of 3 and 4 feet, the other, the normal, mostly recumbent, and less densely clothed with leaves. *Dillwynia hispida*, a low growing species, and *D. patula*, a wiry, much branched, shrub are both rather local, and *Aotus villosa*, hitherto enumerated as from other parts of the colony only, abounds in all the northern scrub country. *Acacia colletoides*, a thorny species, is not common on the outskirts of the deserts, and the occurrence of *A. Mitchellii* in the Little Desert seems not to be generally known. Large areas covered with *Loudonia Behrii* occur, which, when in bloom, appears a mass of bright yellow. Of the same order of plants we may enumerate *Haloragis elata*, a tall, coarse species, delighting in sandy soils. The natural order Myrtaceæ is largely represented by the genera *Darwinia*, *Baeckea*, *Kunzea*, *Melaleuca*, *Callistemon*, and *Eucalyptus*. *Darwinia micropetala* grows only in one locality in the Little Desert, and was first collected there by the author. It exists as a small shrub, adorned with headlets of small, whitish flowers. One of the most widely diffused plants is *Baeckea crassifolia*, and one of the first to bloom in the scrub, the flowers varying in tint from white to deep pink. *B. Behrii* is a tall species of sandier soils, blooming late. *Kunzea pomifera* is a procumbent trailing plant, forming large patches on the sandiest soils. Strange to say, that although it produces blossoms freely, it seems never to perfect its fruit. On the Coorong, and near the mouth of the Murray River, the fruits are eaten, and are known as "muntry" berries. In places liable to periodical inundations *Callistemon coccineus* occurs, also a variety of *Melaleuca pustulata* of dwarf habit, associated with *M. gibbosa*. *M. acuminata* and *M. Wilsonii* are both partial to sandy soils, the latter presenting a fine appearance when in bloom. *Eucalyptus hemiphloia* is a species partial to sandy country. The genus *Cryptandra* is represented by *C. subochreata*, *C. vexillifera*, *C. leucophracta*, and *C. spathulata*. The two first-named are widely diffused, extending over the whole of the desert country; the second abounds in three varieties, one of which is comparatively tall, producing moderately large

heads of flowers; the other, a small variety of the first, and the third is low-growing, and differs both in shape of leaf and time of flowering from the other two. *C. spathulata* was supposed to be confined to South Australia; but the writer gathered specimens some miles east of the South Australian Border line. A fifth species, collected by the writer, for the first time in Victoria, is supposed to be identical with *C. bifida*, a species hitherto known only from Kangaroo Island. Baron von Mueller was unable to decide whether it was a new species or not, in the absence of ripe fruit, which, unfortunately, could not be obtained. The plant, to the writer's knowledge, exists only on one range in the Little Desert, which has been recently swept by bush fires, and all plants of the *Cryptandra* are, therefore, destroyed. There are only two or three representatives of the order, *Umbelliferae*, to be found in the desert country, such as *Didiscus pusillus*, and *Xanthosia dissecta;* the latter being local in the Little Desert. On most sandy rises grow the Quandong (*Santalum* (*Fusanus*) *accuminatum*), as a small tree of drooping habit. The *Grevilleas* are well represented by the following:—*G. pterosperma*, *G. Huegelii*, *G. lavandulacea*, *G. aquifolium*, and *G. rosmarinifolia.* The two first named are confined to the scrub country of the Great and Little Desert, *G. Huegelii* being noted for the brilliancy of its flowers. The composite order is represented by a large number of genera, particularly the Aster family *A. exul;* *A. Huegelii*, and *A. picridifolius* being the most noticeable. The last named is a comparatively new species, bearing purple-rayed flowers. *A. exul* is a robust species, bearing large purple-rayed flowers, and emitting an unpleasant smelling, sticky exudation. *Calotis cymbacantha* occurs only in the northern deserts, and bears large, yellow-rayed flowers. *Podolepis Siemssenia* is a graceful little species from the northern deserts. *Waitzia corymbosa* is fairly common on the sandhills west of Lakes Hindmarsh and Albacutya, and presents a gay appearance when in flower. *Humea squamata*, a species first discovered by the writer, is fairly common, as a tall shrub in all the desert country. *Eriochlamys Behrii* is known only from one locality near the Wimmera River. A plant also noticed in the Grampians, extending to the desert country of this region, namely, *Senecio magnificus*, a large flowering species, the leaves of which used to be cooked and eaten as a vegetable by the station hands. One species of *Dampiera*, *D. marifolia*, may be regarded as strictly confined to this part of the colony. Also *Scaevola spinescens*, a prickly bush, bearing straw-coloured flowers; rather rare. *Scaevola aemula* is common on the northern sandhills. The solanaceous plant, *Anthocercis myosotidea*, is only to be found on the sandhills at and near Lakes Hindmarsh and Albacutya, as a small herbaceous plant, bearing purple flowers. Of the order, *Schrophularinæ*, we have *Stemodia Morgania*, to be

found here and there in sandy, springy soils. This plant is considered to be poisonous, as neither sheep nor cattle will touch it, although it remains green when everything else is burnt up. *Limosella Curdieana* is an aquatic, found in most permanent waterholes. The number of Epacridaceous plants inhabiting the scrub country is also large, but the only one which may be regarded as entirely confined to this region is *Styphelia cordifolia*, a tall growing species, with small flowers, and cordate leaves, of very rare occurrence. *S. Sonderi* is found widely diffused. The conifers are represented by *Callitris verrucosa* and *C. cupressiformis*, both of frequent occurrence. The grasses confined to this region are not very many, the most noticeable being *Panicum decompositum*, *Neurachne alopecuroides*, *Aristida Behriana*, *Stipa elegantissima*, *Stipa aristiglumis*, *Poa ramigera* in swampy places. *Diplachne fusca*, *Triodia irritans* and *Triraphis mollis*. The order Orchideæ is also well represented, but only by species extending to other parts of the colony.

The plants which are to be found on and around Mount Arapiles, but extending no further west, are for the most part identical with those found in similar situations in the Grampian Mountains. A few are, however, not existing to the writer's knowledge, anywhere else, but at Mount Arapiles. In the rockiest and most inaccessible gullies, may be found the malvaceous plant, *Howittia trilocularis;* a tall shrub, bearing purple blossoms. On the summit of the mountain grow large bushes of the showy *Eriostemon obovalis*, and in the scrub around the base are a few scattered bushes of *Prostanthera spinosa*, a thorny species of low growth bearing large white flowers dotted with purple in the throat. At the base grow also large clumps of *Acacia rupicola*, a species which when bruised emit a pleasant scent. *Phyllanthus Gunnii* occurs sparsely as a graceful small tree in the principal gully on the west side of the Mount. On paying a subsequent visit to the locality, it was found that the shrubs had disappeared, being killed by rabbits or bush fires. Large trees of *Pittosphorum phillyræoides* grow on the limestone rises not far from the base of the Mount, having stems quite 18 inches in diameter. In the clefts of the Mitre rock grow a few bunches of *Psilotum triquetrum*, a plant found nowhere else in Victoria, specimens of which were first gathered by the writer and submitted to Baron von Mueller, and compared with some which he gathered himself in the Port Jackson district many years ago. A variety of *Correa speciosa* of tall growth with whitish flowers bearing some resemblance to *C. Lawrenciana* of the Grampians occurs in all the gorges, and in the crannies of the rocks grow a large variety of *Alternanthera triandra*. *Epacris impressa* is represented by a variety with larger and deeper coloured flowers than those of the sort prevalent in the Little Desert

where any but white-flowering plants are rarely met with. *Senecio odoratus* and *Sambucus Gaudichaudiana* occur also in the gorges. One large bush of *Adriana quadripartita* used to grow on a sand rise not far from the Mount, the only one apparently in the district. A certain class of plants occur only in the open country, north of the Great Desert, between it and the Murray River. This open country consists of plains, interspersed with sand ridges, covered with pines, and belts of mallee. Limestone and gypsum abound, the latter, as before described, mostly in little round hillocks. On the plains grow bushes of *Nitraria Schoberi*, and on the drier soils may be found the various salt bushes such as *Atriplex nummularium*, nearly extinct; *A. rhagodioides*, *A. leptocarpum*, and *A. holocarpum;* also *Kochia stelligera*, *K. brevifolia*, and *K. ciliata*. *Tribulus terrestris* is common on the lower-lying lands, and is credited with laming sheep. *Plagianthus microphyllus* and *M. spicatus* delight in the salty soils; but neither are very common. Further north towards the Murray, specimens of *Heterodendron oleæfolium*, a small tree or rather bush, may be obtained; but they seem to flower at rare intervals, and there is never any fruit observed. The genus *Cassia*, is represented by *C. Sturtii* and *C. desolata*, but not in any great quantity. *C. Sturtii* is particularly abundant close to Lake Albacutya. *Acacia microcarpa*, *Acacia farinosa*, and *A. homalophylla* are occasionally to be met with. *Exocarpus aphylla*, an unattractive looking small tree, is common on the rises. At rare intervals may be met small clumps of *Capparis Mitchelli*, which is regarded as the showiest plant of the district.

Of the composites, we have here *Athrixia tenella*, *Aster calcareus*, *Senecio platylepis*, not to be found south of the Great Desert. *Logania nuda* exists sparsely on the scrubby patches. The minute annual *Drymaria filiformis*, hitherto known from South and West Australia only, was first discovered as new to this colony by the writer, who gathered specimens in this region, as well as subsequently in the more southern scrubs. Aquatic plants, except along the Murray, are not numerous, but in most permanent dams or reservoirs, such plants as *Ottelia ovalifolia*, *Valisneria spiralis*, *Hydrilla verticillata*, and *Alisma plantago* have established themselves, besides other plants found in the more southern parts of the colony. On salt marshes, in a few places, *Heliotropium curassavicum* may be found growing, associated with the following:—*Salicornia robusta*, *S. arbuscula*, and *Muehlenbeckea polygonoides* in the fresh water patches. *Glycyrrhiza psoraloides* is a species partial to the dry bed of swamps. *Lobelia concolor* and *Isotoma axillaris* abound in all wet places. Amongst those omitted to be mentioned as confined to certain parts of the Little Desert, is *Thysanotus Baueri*, a species bearing some resemblance to *T. tuberosus* of the Grampians. Two species of fresh water algæ

(Nitella), have been noticed in permanent dams of water, one of which has an offensive odor communicable to the water. Besides these already enumerated we have the following plants established in the district which are common to other parts of the colony, but which have not been as yet enumerated amongst those extending to the north-west portion of the colony :—*Viola betonicifolia*, *Tetratheca ciliata*, *Pseudanthus ovalifolius*, *Beyeria viscosa*, *Stackhousia viminea*, *Sagina apetala*, *Gompholobium Huegelii*, *Hovea heterophylla*, *Loranthus celastroides*, *Lagenophora Emphysopus*, *Xanthorrhœa minor* and *X. australis*, *Cryptandra tomentosa*, *Alchemilla vulgaris*, *Acaena sanguisorbae*, *Haloragis micrantha*, *Lhotzkya genetylloides*, *Myriophyllum pedunculatum*, *Exocarpus stricta*, *Opercularia varia*, *Lobelia simplicicaulis*, *Candollea perpusilla*, *Cuscuta tasmanica*, *Polypompholyx tenella*, *Prostanthera rotundifolia*, *Verbena officinalis*, *Styphelia adscendens*, *S. humifusa*, *S. strigosa*, *S. rufa*, *S. Woodsii*, *S. serrulata*, *S. scoparia*, *Brachyloma daphnoides*, *B. ciliatum*, *Dipodium punctatum*, *Spiranthes australis*, *Thelymitra ixiodes*, *Thelymitra antennifera*, *Calochilus Robertsoni*, *Corysanthes pruinosa*, *Pterostylis nutans*, *P. vittata*, *P. mutica*, *Calectasia cyanea*, *Xerotes Thunbergii*, *Ruppia maritima*, *Trithuria submersa*, *Lepyrodia interrupta*, *Scirpus nodosus*, *Cladium radula*, *Lepturus cylindricus*, *Aira cæspitosa*, *Danthonia carpoides*, *Grammitis rutifolia*. The following plants also occur plentifully, and which are described as inhabiting the whole of the colony excepting, perhaps, the eastern and north-eastern district :—*Myosurus minimus*, *Ranunculus lappaceus*, *R. rivularis*, *R. parviflorus*, *Hibbertia densiflora*, *H. stricta*, *H. fasciculata*, *Papaver aculeatum*, and the introduced *P. incisa*, *Nasturtium terrestris*, *Cardamine laciniata*, *Capsella elliptica*, *Lepidium ruderale*, *Bursaria spinosa*, *Cheiranthera linearis*, *Drosera glanduligera*, *D. auriculata*, *D. Whittakerii*, *D. Menziesii*, *Elatine americana*, *Hypericum japonicum*, *Comespera calymega*, *Correa speciosa*, *Zygophyllum Billardieri*, *Linum marginale*, *Geranium carolinianum*, *Erodium cygnorum*, *Pelargonium australe*, *P. Rodneyanum*, *Oxalis corniculata*, *Lavatera plebeja*, *Thomasia petalocalyx*, *Poranthera microphylla*, *Beyeria opaca*, *Parietaria debilis*, *Casuarina quadrivalvis*, *C. distyla*, *Dodonaea viscosa*, three varieties; *Stackhousia linariifolia*, *Frankenia laevis*, two varieties, one of which was regarded by Hooker as a distinct species, under the name of *F. thymoides* or *F. pauciflora*, *Claytonia calyptrata*, *C. pygmaea*, *C. australasica*, *C. corrigoloides*, *Stellaria pungens*, *S. multiflora*, *S. flaccida*, *Spergularia rubra*, *Ptilotus macrocephalus*, *P. erubescens*, *P. spathulatus*, *Rhagodia Billardieri*, *R. nutans*, *Chenopodium carinatum*, *C. microphyllum*, *Enchylaena tomentosa*, *Suaeda maritima*, *Salsola kali*, *Rumex Brownii*, *Polygonium prostratum*, *P. hydropiper*, *Muehlenbeckia adpressa*, *M. Cunninghami*, *Daviesia ulicina*,

Eutaxia empetrifolia, two varieties, the one prostrate, and the other tall and upright; *Dillwynia ericifolia*, *D. floribunda*, *Platylobium obtusangulum*, *Templetonia Muelleri*, *Kennedya prostrata*, *K. monophylla*, *Acacia diffusa*, *A. armata*, *A. pycnantha*, *A. myrtifolia*, *A. melanoxylon*, *Tillæa verticillaris*, *T. purpurata*, *T. macrantha*, *Epilobium tetragyna*, *Myriophyllum variifolium*, *M. elatinoides*, *Callitriche verna*, *Calycothrix tetragona* (one variety of this produces deep crimson flowers later in the season than the others), *Thryptomene ciliata*, *Leptospermum lævigatum*, *L. myrsinoides*, *L. scoparium*, *Melaleuca parviflora*, *Eucalyptus capitellata*, *E. rostrata*, *Hydrocotyle laxiflora*, *H. callicarpa*, *Daucus brachiatus*, *Leptomeria aphylla*, *Exocarpos cupressiformis*, *Loranthus exocarpi*, *L. linophyllus*, *L. pendula*, *Isopogon ceratophyllus*, *Adenanthos terminalis*, *Comosperma patens*, *Persoonia juniperina*, *Hakea rostrata*, *Banksia marginata*, *B. ornata*, *Pimelia humilis*, *P. serpyllifolia*, *P. flava*, *P. curviflora*, *P. octophylla*, *P. phylicoides*, *P. stricta*, *Asperula oligantha*, *Galium umbrosum*, *Lagenophora Billardieri*, *Brachycome debilis*, *B. ciliaris*, *B. multifida*, *B. exilis*, *B. collina*, *B. graminea*, *Minuria leptophylla*, *Calotis scabiosifolia*, *Aster ramulosus*, *A. lepidophyllus*, *A. microphyllus*, *Vittadinia australis*, *Stuartina Muelleri*, *Gnaphalium luteo-album*, *G. japonicum*, *G. indutum*, *Podotheca angustifolia*, *Podolepis acuminata*, *Leptorrhynchus squamatus*, *L. pulchellus*, *L. elongatus*, *L. medius*, *Helipterum incanum*, *H. exiguum*, *Helichrysum Baxteri*, *H. leucopsidium*, *H. Blandowskianum*, *H. apiculatum*, *H. semipapposum* (in two varieties), *H. lucidum*, *Rutidosis pumilio*, *Millotia tenuifolia*, *Calocephalus citreus*, *Craspedia Richea*, *Cotula coronopifolia*, *Centipeda Cunninghamii*, *C. orbicularis*, *Senecio lautus*, *S. brachyglossus*, *Erechtites hispidula*, *Cymbonotus Lawsonianus*, *Microseris Forsteri*, *Lobelia pratioides*, *Wahlenbergia gracilis*, *Candollea serrulata*, *C. despecta*, *Leewenhookia dubia*, *Brunonia australis*, *Dampiera lanceolata*, *D. rosmarinifolia*, *Goodenia geniculata*, *Velleya paradoxa*, *Limnanthemum exaltatum*, *Sebaea ovata*, *Erythræa australis*, *Mitrasacme paradoxa*, *M. distylis*, *Plantago varia*, *Samolus repens*, *Convolvulus erubescens*, *Dichondra repens*, *Wilsonia rotundifolia*, *Solanum nigrum*, *Nicotiana suaveolens*, *Mimulus repens*, *Gratiola pedunculata*, *Limosella aquatica*, *Veronica calycina*, *V. peregrina*, *Euphrasia Brownii*, *Utricularia dichotoma*, *Cynoglossum suaveolens*, *Mentha saturejoides*, *Ajuga australis*, *Styphelia virgata*, *Brachyloma ericoides*, *Diuris maculata*, *Prasophyllum patens*, *P. fuscum*, *Microtis porrifolia*, *Pterostylis barbata*, *Lyperanthus nigricans*, *Eriochilus autumnalis*, *Caladenia Patersoni*, *C. carnea*, *C. coerulea* *C. deformis*, *Glossodia major*, *Hypoxis glabella*, *Dianella revoluta*, *Wurmbea (Anguillaria) dioica*, *Burchardia umbellata*, *Bulbine bulbosa*, *B. semibarbata*, *Thysanotus Patersoni*, *Caesia vittata*, *C. parviflora*, *Chamescilla corymbosa*, *Trycoryne elatior*,

Arthropodium strictum, *A. minus*, *A. paniculata*, *Bartlingia sessiliflora*, *Xerotes effusa*, *X. micrantha*, *X. leucocephala*, *X. Thunbergi Typha augustifolia*, *Lemna trisulca*, *L. minor*, *Triglochin centrocarpa*, *T. mucronata*, *T. procera*, *Potomogeton natans*, *Juncus planifolius J. bufonius*, *J. communis*, *J. pallidus*, *Centrolepis polygyna*, *C. glabra*, *C. aristata C. strigosa*, *Cyperus vaginatus*, *Scirpus fluitans*, *S. cartilagineus*, *S. lacustris*, *Schœnus apogon*, *Lepidosperma laterale*, *L. carpoides*, *Cladium junceum*, *Anthistiria ciliata*, *Ehrharta stipoides*, *Stipa semibarbata*, *S. crinita*, *Pappophorum commune*, *Poa cæspitosa*, *P. fluitans*, *Distichlis maritima*, *Eragrostis Brownii*, *Azolla filiculoides*, *Marsillea quadrifolia*, *Ophioglossum vulgatum*, *Cheilanthes tenuifolia*, and *Pteris aquilina*.

There are still about 320 species of plants, found only in the north-west portion of the colony, which hitherto have not been noticed by the writer, but which probably occur in parts not yet visited by him.

The number of species collected altogether from the district by the writer was 523, which were named and classified from time to time by the late Baron von Mueller, and to whose unselfish aid, and untiring energy, the author owes what knowledge he has acquired of the botany of Victoria.

No. 4.—NOTES ON THE FLORA OF BATHURST AND ITS CONNECTION WITH THE GEOLOGY OF THE DISTRICT.

By W. J. Clunies Ross, B.Sc., Lond., F.G.S.

(*Read Monday, January* 10, 1898.)

The subject of local floras is of considerable interest to the botanist, especially if, in addition to merely enumerating the plants found in a district, a study is made of the causes which produce the variation from the floras of other centres, and if observations are made of the variations within the district itself.

There can be little doubt that climate has a predominant influence on the flora of a district ; including under the term climate the results due to elevation, average temperature and rainfall, prevailing winds, &c.

There are other agencies, however, which help to influence the flora, and among these the soil and drainage of the country are specially notable. But the soil is closely related to the geology of

a district, so that the geologist and botanist may mutually help one another to a considerable extent. The botanist, by indicating the limits within which certain plants are found, may assist the geologist in drawing the lines between different formations, if it can be shown that the plants in question affect particular classes of rocks. The geologist, on the other hand, can point out to the botanist the different characters of the rocks at various places, and thus help to explain the reason for what had previously only been observed.

To obtain, however, such a critical acquaintance with the flora of a district as to enable one to speak with confidence as to the limits within which particular species of plants are found requires a thorough knowledge of the country, and such as can hardly be obtained without a continuous residence for several years within the district. If followed up systematically, the results are, nevertheless, likely to be both interesting and useful, and it is as a slight contribution to the study of local floras in connection with geology that these notes, relating to a particular district of New South Wales, are written.

Before dealing with the plants of the Bathurst district, and their distribution within the same, it will be well to consider briefly what we may expect to find out about them. It is proverbially difficult to prove a negative; and the mere fact that a species of plant, well-known at one place, which we may call A, has not been recorded from another, B, does not prove that it may not be found at B subsequently. Seasons vary, and a plant may be common one year and very rare the next. Again, many plants have only a short period of flowering, and unless seen at that time are very liable to be overlooked or confounded with other species. Considerations such as these inculcate caution in arriving at decisions. Nevertheless, if, after working for some years, one finds that certain plants are almost always obtainable at one place, while on a different class of rock in the neighbourhood they have never been found, one may reasonably say that they are absent from the latter. Moreover, the occurrence of one or two isolated specimens at B would not entitle us to class it with A as a favourable locality for the plant. Knowing how widely seeds may be diffused, it could hardly be expected that a plant would not occasionally spring up in an unfavourable locality, but if it failed to maintain a footing it would be good evidence that the soil and surroundings were not sufficiently favourable to enable it to succeed in the battle of life. As an illustration of what is meant, the case of the well-known Cornish heath, *Erica vagans*, may be cited. This plant has a very limited range in England, being almost confined to the Serpentine in the neighbourhood of Lizard Point. It is said to occur occasionally on Devonian rocks in Cornwall, but is not common there, so that, if found growing

luxuriantly, it would indicate probable Serpentine in the immediate neighbourhood. Similarly, in the valley of the Thames, one can often predict an outcrop of London clay by seeing a clump of large trees, elms or oaks, growing together, since those trees are not nearly so common on the subjacent lower London Tertiaries.

PHYSIOGRAPHY OF BATHURST.

In order to understand some of the peculiarities of the Bathurst flora, a brief account of the physiography of the district may be given. The city of Bathurst is at a height of about 2,200 feet above sea-level, and is at the centre of a tract of undulating country known as the Bathurst Plains. At a distance of about 10 miles from the city, hills rise all round the plains, and reach a height of from 1,000 to 2,000 feet above them. The climate is generally dry, with a moderate but very variable rainfall, ranging from 15 to 34 inches in the year. There are considerable fluctuations in temperature, the average daily range being greater than that of almost any other place in New South Wales. The winters are of moderate severity, the temperature sometimes falling below 20° F. for several nights in succession, while the summer temperature may reach 105° in the shade. The rainfall is irregularly distributed throughout the year. Under these conditions, it need hardly be said that the flora is essentially different from that of the coastal districts of the colony, with their equable temperature and heavier rainfall, and one would not expect to find it very rich or varied. Geologically, there are three distinct formations within the district. These are—1 Granite, 2 Silurian, 3 Devonian. The whole of the plains is included in the granite area. In places the granite is covered with beds of drift gravel, and in the immediate neighbourhood of Bathurst there are hills—Bald Hills, Mount Apsley, Mount Pleasant—capped with basalt. The Bald Hills form by far the most extensive of these outliers of basalt, and certain plants occur there which have not been found on the granite. The granite itself is much decomposed over most of the area, but compact veins and bosses occur in places, and the rock is there seen to be made up of quartz, felspar, black mica, and hornblende, with accessory minerals, such as apatite, sphene, and others. Near the boundary the character of the granite changes somewhat, especially on the west of Bathurst. This change in the granite seems to be accompanied by a change in the flora which is richer there than over the rest of the plains. Silurian rocks form most of the hills which surround the plains. They consist of slaty and schistose rocks, with beds of limestone in places. Quartz reefs are not uncommon and mineral veins of various kinds also occur, including some of copper ore which have been worked to a considerable extent. Silver ores are also found at several localities.

Devonian rocks rest on the silurian to the east of Bathurst. They are mostly grits and quartzites, and are rarely found at a height of less than 1,000 feet above Bathurst.

The Bathurst Plains have been cultivated for the last sixty years, and although the soil does not appear promising at first sight, good crops of wheat are obtained in favourable years. Most of the Silurians and Devonians remain in the condition of bush, but they have been cultivated in places, and there are some successful orchards on these rocks.

FLORA OF BATHURST.

When a visitor comes to Bathurst and proceeds to examine the flora he is likely to think that it is in a state of abject poverty. This does not apply to the actual number of plants, for the ground is often covered with flowers, but to the variety and interest of the flora, most of the plants being common and widely diffused weeds, such as *Geranium dissectum*, *Helichrysum apiculatum*, *Wahlenbergia gracilis*, *Goodenia pinnatifida*, together with the introduced *Medicago maculata*. More careful examination at different seasons of the year shows that a considerable addition may be made to the meagre list, but, after years of searching, one has to admit that the flora is decidedly limited in variety. As much of the country has been so long under cultivation this might account for the destruction of the native flora, but there are some patches of bush, and the slopes of the Bald Hills, which have only been lightly grazed, so that it is not likely that many species have been exterminated. On approaching the boundaries of the granite in certain directions one finds some new plants, but the variety is still limited until one reaches the Silurian rocks. Then a change is at once noted. Instead of open land, with scattered trees and well grassed, one finds numerous shrubs and stunted gum-trees, with detached tussocks of coarse grass and much bare ground. Although the soil appears to be comparatively barren and decidedly poorer than the granite, yet one finds a much greater variety of plants, which are for the most part quite distinct from those met with on the granite. There is some difference in the flora on the different sides of Bathurst, yet for the most part, the Silurian flora is of the same type all round the district, although the rocks vary considerably, sometimes being slightly altered slates and phyllites, sometimes true mica schists, and highly mineralized, with the limestone changed to dolomite.

As one passes along the slopes to the east of Bathurst, where the Silurian rocks are partly covered with downwash from the Devonians, the flora appears to become poorer. On the Devonian rocks themselves the gullies are fairly well covered with plants,

including some not found on the other formations. When we reach the top of the rise to the east of Bathurst, we find that instead of detached hills there is really a table-land, intersected by deep gullies. There is little variety in the plants, but dense scrubs occur in places formed of various plants, notably *Daviesia latifolia.*

Collections have been made from all the formations, but most completely from the granite. The Silurians cover a wide area, and as they only commence at an average distance of at least 10 miles from Bathurst, one has not the opportunity of visiting a number of different localities at various seasons of the year, and for several successive years, as one would have if they were nearer the city. The same, but rather greater, difficulties attend the study of the Devonian flora. It is therefore likely that a good many additional names will eventually be added to the lists which have been compiled. Nevertheless, most of the plants growing on the different formations have probably been collected, and at any rate enough specimens to enable one to draw some conclusions as to the distribution of the flora of the district. Of course one is dealing with a comparatively limited area, but Silurian and Devonian rocks, and also granites, of similar character to those found around Bathurst are widely distributed throughout this colony, and also occur in Victoria, so that those who have the opportunity may continue the observations in other centres.

We may, therefore, now pass on to consider some of the peculiarities of the flora in detail, and, to illustrate the variation of the flora on the different formations, may take a few typical groups of plants.

The wattles form an interesting and characteristic series. *Acacia dealbata*, as might be expected, is common on the granite, the Silurian and the Devonian, so that it is useless for distinguishing the rocks. Around Bathurst itself few wattles occur. *A. implexa* flourishes on the Bald Hills, and *A. crassiuscula* occurs on the drift and granite at one or two places. With these exceptions, we do not meet with any wattles until we approach the boundary or actually pass on to the Silurian. Then we find a considerable variety. On low ground, near streams, *A. vestita* grows well; on the Silurian schists to the south of Bathurst *A. armata* sometimes forms dense scrubs, but is rare or absent on the hills to the east of the city. *A. diffusa* is widely diffused on the Silurian, while *A. lanigera*, *A. vomeriformis*, *A. discolor*, *A. neglecta*, and *A. subporosa* are other species on the same series of rocks. A small-leaved wattle, *A. buxifolia* or *A. lunata*, is often very common, but rarely bears fruit, and sometimes appears to be killed by a parasite. On the Devonian very few wattles have been found; but *A. decurrens*, var. *normalis* has so far only been noted on those rocks.

Of Leguminous plants other than wattles there is a considerable variety. *Indigofera australis* is common on the Silurian just outside the granite, but has not been found on that rock, although the variety *minor* is not uncommon there. *Swainsona phacifolia* and *S. lessertifolia* are very common on the granite, much rarer on the Silurian. *S. galegifolia* has been found at one locality on the Silurian. *Gompholobium Huegelii* is common on the Silurian, absent from the granite. At least three specimens of *Pultenæa* are found on the Silurian, but none on the granite. *Daviesia genistifolia* occurs on the Silurian, but is not common, while on the granite, the variety *colletioides* is found. It is interesting to note that A. Cunningham many years ago mentioned this variety as occurring on "forest land near Bathurst." *D. latifolia* is widely spread, and has been found on granite, Silurian and Devonian, but is not common on the two former. The two small Desmodiums, *D. brachypodium* and *D. varians*, have only been noted on the granite, where they are common, but may occur outside it.

Passing on to the Myrtaceæ, the gums have not been thoroughly worked out yet on the Silurian or Devonian. On the granite, *Eucalyptus melliodora* and *E. Stuartiana* are common, and *E. tereticornis* also occurs. *E. goniocalyx* has been found near the boundary of the granite to the west of Bathurst. On the Silurian, the following may be mentioned:—*E. polyanthema*, *E. viminalis*, *E. macrorrhyncha*, *E. hæmastoma*; and on the Devonian, *E. eximia*, although this species has not been found close to Bathurst.

Of other Myrtaceæ there are few. *Calythrix tetragona* forms scrubs on the Silurian, but does not occur on the granite, and there are one or two *Leptospermums*.

The Proteaceæ are poorly represented in the district. *Banksia marginata* grows on the basalt of the Bald Hills, but has not hitherto been found elsewhere. *Grevillea arenaria*, var. *canescens*, grows on the granite, near the boundary, and on the Silurian; while two more species, *G. acanthifolia* and *G. floribunda*, are found on the latter. *Hakea acicularis* occurs on Silurian and Devonian and *H. microcarpa* on Silurian and the granite of the Bald Hills.

Of the Epacrideæ scarcely any have been found in the granite, although one or two may occur about the boundary, but on the Silurian they are abundant in number, but not very varied. *Leucopogon virgatus* appears to specially flourish near quartz reefs, while *Leucopogon lanceolatus* has only been found on the Devonian. *Styphelia laeta* and *Brachyloma daphnoides* are two of the commonest plants on the Silurian, but do not appear to grow on the granite.

The Compositæ are very abundant in number, and include a fair number of species, but for the most part are not very distinctive. One case may be mentioned, however. *Helichrysum apiculatum* is perhaps our most abundant weed, and occurs everywhere, but *H. bracteatum*, while it grows well on the Silurian, appears to be entirely absent from the granite. In the neighbourhood of Bathurst the succession of Compositæ almost mark the seasons. *Cymbonotus Lawsoniana*, with its broad leaves and yellow flowers, is the first to appear. Then this disappears, and *Microseris Forsteri* takes its place. A little later the ground is covered with one or two species of *Brachycome*, which do not last long, while *Helipterum incanum* and *Helichrysum apiculatum* last through the whole summer.

Of Rhamnaceæ, *Pomaderris apetala* has only been found on the Devonian, while *P. prunifolia* occurs on the Silurian, *Cryptandra amara* on granite and Silurian, and *Discaria australis* on the same, but uncommon. The Orchids form an interesting group. Several species of *Diuris* are found on the granite near Bathurst: in the early spring *D. aurea* and *D. sulphurea*, and later, *D. elongata*. These are uncommon on the Silurian, while *D. maculata* is common on the Silurian, but very rare on the granite. *Glossodia major* is very common on the Silurian and near the boundary of the granite, but never seems to occur near Bathurst. Two species of *Thelymitra*, *T. ixioides*, and *T. longifolia*, are common on the Silurian, as are two *Caladenias*, *C. dilatata*, and *C. dimorpha*, but not one of these occurs on the granite, or if they do, are very rare.

If one came upon *Stypandra glauca*, one of the Liliaceæ, growing freely, it would be good evidence near Bathurst that one was on the Silurian, or very close to it, since it is not found on the granite; but care would be required not to confuse a *Dianella*, of somewhat similar habit, with it, since this is not uncommon on the granite.

A tolerably complete collection of grasses from the granite has been made. The Silurian and Devonian have not been so completely worked, but the grasses on the granite appear to differ considerably from those on the other formations. Altogether seventeen species have been obtained from the granite, of which only three or four occur on the Silurian as well, while four species have been recorded from the Silurian alone.

Many more particulars might be given, but enough has been said to show that the difference between the flora of the granite and that of the Silurian is very marked. Of course one can hardly suppose that plants have special affinities for rocks of a particular age; but if we find that rocks of similar composition and age in different parts of the colony have similar floras, an important step

towards classifying our rocks will have been made. There can be little doubt that the main cause determining the flora of the district, apart from climate, is the character of the soil, but it does not follow that an ordinary analysis of a soil will indicate its fitness for particular plants. An analysis, as a rule, only furnishes the percentage of acids and bases which are present in weighable quantities in an average sample. But there may be rarer elements present in small quantities, and these are not usually looked for, although they may be of importance to some plants. The ash of tobacco is said nearly always to contain lithium, so that this element must be widely diffused, but it is not likely to be looked for in an analysis, and the same is true of other elements, such as fluorine. Something has been done to trace the association of certain elements with particular species of plants, but, with few exceptions, very few definite results appear to have been obtained. Mr. S. B. J. Skertchly has recently treated the subject of the, so-called, copper plant, *Polycarpæa spirostylis*, F.v.M., which is said to accompany copper lodes, in his report (Geological Survey, Brisbane, 1897) on the Tin mines of Watsonville, Queensland, in which he also alludes to some literature in reference to similar cases. So far, the writer has not noticed anything of the kind, except the apparent abundance of *Leucopogon virgatus* in the neighbourhood of quartz reefs, which may be only a local peculiarity.

Another point worthy of consideration in dealing with the distribution of plants, especially in relation to their abundance or scarcity in particular seasons, is the action of parasites, animal or vegetable.

The parasites of cultivated plants have been carefully studied, although even with these it is not always easy to say why they are so much commoner in some seasons than in others. Much less attention has been bestowed on the parasites of wild plants, and yet they are equally interesting to the botanist. To take the case of a common weed; a few years ago the mallows, which are very common at the sides of roads and in small paddocks about Bathurst, were extensively attacked by a rust, *Puccinia malvacearum*, which also attacked Hollyocks and other plants belonging to the same order, Malvaceæ. For several years the mallows appeared to be not nearly so common. This year, 1897, they have been excessively abundant, but do not seem to be rusted.

Another case noted by the writer is that of a *Cassytha*, probably *C. glabella*. This parasite attacks several kinds of plant, but seems to be selective in the choice of its host. Last year, 1896, a small-leaved wattle, probably *A. buxifolia*, was very abundant, as a shrubby plant, on the Silurian in early spring. Later hardly one was to been seen alive. Many had evidently been badly attacked by *Cassytha*, and may have been killed by it. *A. diffusa*,

although growing on the same ground, did not seem to be touched by the parasite, although it was found on a *Pultenæa* and a *Dodonæa*, two very different plants. They, however, did not seem to be injured much. This spring, 1897, very little *Cassytha* is to be seen, and *A. buxifolia* is also scarce. The latter are small and stunted, but do not seem to be attacked, the only specimens of *Cassytha* obtained being on a *Leptospermum* and a *Brachyloma*. A much stouter *Cassytha* sometimes attacks gum-trees, and seems to kill them, but is uncommon, and I have not found it in flower or fruit.

A mistletoe, *Loranthus pendulus*, is not uncommon on gum-trees growing on the Silurian, but I have not found it on those growing on the granite, nor have I determined whether it favours particular species of Eucalypts in preference to others.

Another matter worthy of investigation is the excessive abundance of a particular weed one year and its almost entire absence the next. In the early part of 1896, the gardens and paddocks around Bathurst were completely overgrown by the introduced weed *Amarantus paniculatus*, Linn. It seemed to drive out almost all other weeds, and was noted in many other districts. So far as Bathurst is concerned it was not very common before 1896, although it is said to have been known in the Kempsey district for twenty years.* One naturally expected to see it equally abundant the following year, but very few plants were to be seen. The seasons were very similar, both dry, and there was no apparent parasite to account for its disappearance. This summer it appears likely to be common again. This weed was rarely found in the open country, and never in the bush. It appears in fact to be a tolerably general rule that introduced weeds cling to civilisation and seldom become acclimatised in the bush. It would be easy to compile a list of about a dozen common weeds found in Bathurst, or close to it, which are rare in the open country, while others extend their range over fallow fields, but in no case do we find them in the bush. Only three or four cases have been noticed in which introduced plants seem to be able to hold their own in land which has never been cultivated. Other observers in different parts of the country may not have had the same experience, but so far as this district is concerned there appears to be little danger of the native flora being driven out by introduced plants so long as considerable areas of bush land remain.

A census of the Bathurst flora has been prepared showing the formations on which the various species have been found. Very nearly all have been actually collected by the writer, in only a few cases specimens collected by others having been accepted.

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* *Agricultural Gazette* of New South Wales, vol. vi, 1896, p. 299; also vol. vii, 1896, p. 428.

A census of the flowering plants of Bathurst, New South Wales, showing the geological formations upon which the plants have been found.

	Granite.	Silurian.	Devonian.
CLASS I—DICOTYLEDONS.			
SUB-CLASS—POLYPETALÆ.			
SERIES I—THALAMIFLORAE.			
Caryophyllaceæ—			
Spergularia rubra	×	....	....
Stellaria pungens	....	×	....
Hypericineæ—			
Hypericum japonicum	×	×	....
Malvaceæ—			
Hibiscus trionum	×	....	....
Sida corrugata	×	....	....
Pittosporeæ—			
Billardiera scandens	....	×	....
Bursaria spinosa	×	×	×
Cheiranthera linearis	....	×	....
Polygaleæ—			
Comespermum ericinum	....	....	×
Polygala sibirica	×	....	....
Portulacaceæ—			
Portulaca oleracea	×	....	....
Ranunculaceæ—			
Clematis microphylla	....	....	×
Ranunculus lappaceus	×	×	....
R. rivularis	×	....	....
Violaceæ—			
Viola betonicæfolia	....	×	....
Dilleniaceæ—			
Hibbertia diffusa	×	×	....
H. stricta	....	×	....
SERIES II.—DISCIFLORAE.			
Geraniaceæ—			
Geranium dissectum	×	....	....
Pelargonium australe	× B	....	....
Oxalidaceæ—			
Oxalis corniculata	×	×	....
Linaceæ—			
Linum marginale	×	×	....
Rhaumaceæ—			
Cryptandra amara	×	....	....
Discaria australis	×	....	....
Pomaderris apetala	....	....	×
P. prunifolia	....	×	....
Rutaceæ—			
Correa speciosa	× B	....	....
Stackhousieæ—			
Stackhousia monogyna (linariifolia)	×	×	×
Sapindaceæ—			
Dodonea viscosa	....	×	....
D. lobulata	× B	×	....

CLASS I—DICOTYLEDONS—*continued.*

SUB-CLASS—POLYPETALÆ—*continued.*

SERIES III.—CALYCIFLORAE.

	Granite.	Silurian.	Devonian.
Araliaceæ—			
Astrotriche ledifolia	....	×	....
Panax sambucifolia	....	×	....
Droseraceæ—			
Drosera peltata	×	×	....
Leguminosæ—			
Acacia dealbata	×	×	×
A. decurrens, var. normalis	....	....	×
A. diffusa	× B	×	....
A. armata	....	×	....
A. crassiuscula	×	....	....
A. buxifolia	× B	×	....
A. discolor	....	×	....
A. implexa	×	....	....
A. juniperina	× B	×	....
A. lanigera	....	×	....
A. neglecta	....	×	....
A. penninervis	....	×	....
A. subporosa	....	×	....
A. vomeriformis	....	×	....
A. vestita	× B	×	....
A. amœna	....	×	....
Pultenæa stipularis	....	×	....
P. styphelioides	×	×	....
Daviesia corymbosa	....	×	....
D. corymbosa, var linearis	....	×	....
D. genistifolia	×	×	....
D. genistifolia, var colletoides	×	....	....
D. latifolia	×	×	×
Dillwynia cinerascens	....	×	....
D. ericifolia	....	×	....
D. floribunda	....	×	....
Hovea heterophylla	×	×	....
Bossiœa buxifolia	....	×	....
Kennedyia monophylla	×	×	×
Swainsona galegifolia	....	×	....
S. lessertifolia	×	....	....
S. phacifolia	×	....	....
Gompholobium Huegelii	....	×	....
Indigofera australis	....	×	....
I. australis, var. minor	×	....	....
Desmodium brachypodium	×	....	....
D. varians	×	....	....
Glycine clandestina	×	....	....
G. tabacina	×	....	....
Goodia lotifolia	....	×	....
Zornia diphylla	×	×	....
Lotus australis	×	×	....

	Granite.	Silurian.	Devonian.
CLASS I—DICOTYLEDONS—*continued.*			
SUB-CLASS—POLYPETALÆ—*continued.*			
SERIES III—CALYCIFLORAE—*continued.*			
Rosaceæ—			
Acæna ovina	×	×	×
A. sanguisorba	×	×	×
Rubus parvifolius	×	×	....
Myrtaceæ—			
Eucalyptus eximia	....	....	×
E. goniocalyx	× B	....	....
E. hæmastoma	....	×	....
E. macrorrhyncha	....	×	....
E. melliodora	×	×	....
E. polyanthema	....	×	....
E. tereticornis	×	....	....
E. stuartiana	×	×	....
E. viminalis	....	×	....
E. hemiphloia	....	×	....
Leptospermum attenuatum	×	×	....
L. stelligerum	× B	×	....
Calythrix tetragona	....	×	....
Umbelliferæ—			
Hydrocotyle laxiflora	×	....	....
Siebera (Trachymene) ericoides	× B	×	....
S. linearifolia	....	×	....
Eryngium rostratum	×	....	....
Onagraceæ—			
Epilobium tetragonum	×	×	....
SUB-CLASS II.—MONOPETALÆ.			
Boraginaceæ—			
Lappula concavum	×	....	....
Cynoglossum suaveolens	×	....	....
Eritrichum australasicum	×	....	....
Myosotis australis	×	....	....
Convolvulaceæ—			
Convolvulus erubescens	×	×	....
Cuscutaceæ—			
Cuscuta australis	×	....	....
Epacrideæ—			
Brachyloma daphnoides	....	×	×
Lissanthe strigosa	....	×	×
Epacris paludosa	....	×	×
Leucopogon attenuatus	....	×	×
L. virgatus	....	×	....
L. lanceolatus	....	....	×
Monotoca scoparia	....	×	×
Styphelia laeta	....	×	×
Astroloma humifusa	× B	×	....
Gentianaceæ—			
Erythræa australis	×	×	....
Solanaceæ—			
Solanum cinereum	....	×	....
S. nigrum	×	....	....

	Granite.	Silurian.	Devonian.
CLASS I—DICOTYLEDONS—*continued.*			
SUB-CLASS II—MONOPETALÆ—*continued.*			
Labiatæ—			
Ajuga australis	×	×	....
Mentha gracilis	×	×	....
Prostanthera lasianthos	....	×	×
Salvia plebeia	×	....	....
Teucrium corymbosum	× B	×	....
Westringia eremicola	× B	....	....
Scrophulariaceæ—			
Veronica perfoliata	....	×	....
V. Derwentia	....	....	×
Gratiola peruviana	....	×	×
Euphrasia Brownii	×	×	....
Stylideæ—			
Stylidium graminifolium	....	×	....
Goodeniaceæ—			
Goodenia pinnatifida	×	....	....
G. elongata	×	....	....
G. bellidifolia	....	×	....
Dampiera Brownii	×	×	....
Verbenaceæ—			
Verbena officinalis	×	....	....
Compositæ—			
Calotis dentex	×	×	....
C. lappulacea	×	....	....
Helipterum incanum	×	×	....
H. dimorpholepis	×	×	....
Leptorhynchos squamatus	×	×	....
Helichrysum apiculatum	×	×	×
H. bracteatum	....	×	....
H. semipapposum	×	×	×
Podolepis acuminatus	×	....	....
P. sp. (new species)	×	....	....
Cassinia quinquefolia	× B	×	....
Olearia myrsinoides	....	....	×
Craspedia richea	×	×	×
Sonchus oleraceus	×	....	....
Cymbonotus Lawsoniana	×	×	×
Microseris Forsteri	×	×	....
Erechtites quadridentatus	×	....	....
Gnaphalium luteo-album	×	×	....
Picris hieracoides	×	....	....
Brachycome multifida	×	....	....
B. stricta	×	....	....
Companulaceæ—			
Wahlenbergia gracilis	×	×	×
Isotoma axillaris	....	×	....
Rubiaceæ—			
Galium gaudichaudi	×	×	×
Pomax umbellata	....	×	....

	Granite.	Silurian.	Devonian.
CLASS I—DICOTYLEDONS—*continued.*			
SUB-CLASS III.—MONOCHLAMYDEÆ.			
Amarantaceæ—			
Alternanthera triandra	×	....	
Casuarineæ—			
Casuarina Cunninghamiana	....	×	....
C. quadrivalvis	....	....	×
C. glauca	×	....	....
C. paludosa	....	×	....
Euphorbiaceæ—			
Phyllanthus thymoides	....	×	....
Poranthera microphylla	× B	....	....
Lauraceæ—			
Cassytha glabella	....	×	....
C. sp.	....	×	....
Polygonaceæ—			
Polygonum subsessile	×	....	....
Proteaceæ—			
Banksia marginata	×	....	....
Grevillia acanthifolia	× B	×	....
G. arenaria, var. canescens	....	×	....
G. floribunda	....	×	....
Hakea pugioniformis	....	×	....
H. acicularis	....	×	×
H. microcarpa	×	×	....
Persoonia linearis	....	×	....
P. rigida	....	....	×
Thymeleæ—			
Pimelea linifolia	×	×	....
P. curviflora	×	....	....
P. glauca	×	....	....
P. colorans	....	×	....
P. ligustrina	....	....	×
Loranthaceæ—			
Loranthus pendulus	....	×	....
Santalaceæ—			
Choretrum candollei	....	×	....
C. laterifolium	....	×	....
Exocarpus stricta	× B	×	....
E. cupressiformis	....	....	×
SUB-CLASS IV.—GYMNOSPERMEÆ.			
CLASS—MONOCOTYLEDONS.			
Coniferæ—			
Callitris calcarata	× B	×	....
Liliaceæ—			
Stypandra glauca	....	×	×
Anguillaria dioica	×	×	×
Burchardia umbellata	....	×	....
Asphodelus fistulosus	×	×	....
Dichopogon strictus	×	×	....
Laxmannia gracilis	....	×	....

	Granite.	Silurian.	Devonian.
CLASS I—DICOTYLEDONS—*continued.*			
CLASS—MONOCOTYLEDONS—*continued.*			
Liliaceæ—continued.			
Dianella cærulea	×	....	....
Tricoryne elatior	×	....	....
Thysanotus junceus	×	×	×
T. Patersoni	....	×	....
Alismaceæ—			
Alisma plantago	×	....	....
Juncaceæ—			
Xerotes Brownii	....	×	....
X. filiformis	×	....	....
X. longifolia	× B	×	....
Iridaceæ—			
Patersonia sericea	....	×	×
Orchidaceæ—			
Caladenia dilatata	....	×	....
C. dimorpha	....	×	....
C. congesta	....	×	....
Diuris aurea	×	....	....
D. elongata	×	....	....
D. maculata	....	×	....
D. pedunculata	×	....	....
D. sulphurea	×	....	....
Eriochilus autumnalis	....	×	....
Glossodia major	× B	×	....
Prasophyllum fuscum	×	....	....
Pterostylis mutica	×	....	....
Thelymitra ixioides	....	×	....
T. longifolia	....	×	....
Cyperaceæ—			
Cyperus gunnii	....	×	....
Carex paniculatus	....	×	....
Graminaceæ—			
Bromus arenarius	×	×	....
Anthistiria ciliata	×	×	×
Agropyrum scabrum	....	×	....
Andropogon sericeus	....	×	....
Arundo phragmites	×	....	....
Chlorus truncata	×	....	....
Danthonia penicillata	×	....	....
D. semiannularis	×	....	....
D. carphoides	×	....	....
Dichelachne sciurea	....	×	....
Eragrostis leptostachys	×	....	....
Panicum bicolor	×	....	....
P. crusgalli	×	....	....
Pennisetum compressum	×	....	....
Poa cæspitosa	×	×	×
Sorghum plumosum	×	....	....
Stipa setacea	×	....	....
Sporobolus indicus	×	....	....

No. 5.—A STATISTICAL ACCOUNT OF AUSTRALIAN FUNGI UP TO THE END OF 1897.

By D. McAlpine.

(*Read Monday, January* 10, 1898.)

Having prepared a work for the Victorian Department of Agriculture, entitled "A Systematic Arrangement of Australian Fungi, together with Host-Index and List of Works on the Subject," in which all Australian Fungi known up to the end of 1894 are inserted, and as a record has been kept of all additions since that date, I thought it might prove of some scientific interest to give the results in a statistical form.

To some it may appear premature to attempt such a task, seeing that our knowledge of Australian Fungi is still so meagre, but it will serve at least to mark the progress already made, as well as to provide material for comparison at some future date. Besides, when the gaps in our knowledge of this important division of vegetable life are prominently brought forward, it may be the means of inducing some to attempt to fill them up. On two previous occasions Dr. M. C. Cooke, the eminent mycologist, has provided us with a collected list of Australian species of Fungi, and these will be useful for comparison with the present record.

First, in 1883, Dr. Cooke published "Fungi Australiani" as a supplement to "Fragmenta Phytographiæ Australiæ," by the late Baron von Mueller, in which 1,189 species are recorded, excluding synonyms.

Next, in 1892, Dr. Cooke's "Handbook of Australian Fungi" was published, in which the total number of species given are 2,067.

Then, in 1895, the "Systematic Arrangement of Australian Fungi" was published by myself, containing all species known up to the end of 1894, and numbering 2,284 species.

The following table will show how the species are distributed among the different groups. I have classified them under twelve groups, omitting the Schizomycetes or Bacteria, because they still await investigation at the hands of the specialist.

Table I.—Number of Australian Species of Fungi in 1883, 1892, 1894, and 1897, arranged according to groups.

Groups.	1883.	1892.	1894.	1897.
1. Hymenomycetes	778	1,176	1,266	1,303
2. Gastromycetes	111	166	177	198
3. Uredines	26	70	90	112
4. Pyrenomycetes	89	215	253	285
5. Discomycetes	78	122	128	140
6. Tuberoides	1	2	3	7
7. Hyphomycetes	47	109	123	152
8. Sphæropsides	6	115	128	152
9. Saccharomycetes	...	4	10	10
10. Ustilagines	18	28	39	48
11. Phycomycetes	4	12	15	21
12. Myxomycetes................	31	48	52	52
Totals	1,189	2,067	2,284	2,480

It will be seen that between 1883 and 1892 there is an increase of 878 species, and this increase occurs in each of the twelve groups. The additions are most marked in the Hymenomycetes, Uredines, Pyrenomycetes, Hyphomycetes, and Sphæropsides.

Between 1892 and 1897 there is also an increase of 413 species, and this is partly due to recorded species overlooked by Cooke, but mostly to actual additions to the Fungus-flora. There is an increase in each of the groups, particularly in the Uredines and Pyrenomycetes.

* * * * * * * * * *

If we turn now to a more detailed view of the fungi, and examine their distribution, not only in the various groups, but in the different Colonies, there are many suggestive points of comparison, as shown in the following tables.

Table II.—Number of Fungi in the different Colonies, arranged according to groups, together with those common to Britain.

Groups.	Australia.	W.A.	S.A.	T.	V.	N.S.W.	Q.	B.
1. Hymenomycetes	19	137	151	245	603	266	624	466
2. Gastromycetes ...	5	44	26	46	72	45	92	32
3. Uredines............	...	1	21	24	79	26	28	29
4. Pyrenomycetes ...	9	19	18	65	93	41	132	56
5. Discomycetes......	3	8	10	52	71	12	38	54
6. Tuberoides.........	...	...	1	5	...	...	1	...
7. Hyphomycetes ...	2	14	17	21	80	32	62	57
8. Sphæropsides ...	2	3	13	10	88	11	60	13
9. Saccharomycetes	10	...	...	...	...	...	...	...
10. Ustilagines.........	1	...	14	5	28	11	18	10
11. Phycomycetes ...	...	1	4	7	15	5	5	11
12. Myxomycetes ...	2	16	3	20	13	5	29	38
	53	243	278	500	1,142	454	1,089	766

Table III.—Number and relative proportion of Fungi in the different Colonies in the order of their predominance and proportion of British species.

	No.	Proportion.
Victoria	1,142	46 per cent.
Queensland	1,089	43·9 ,,
Tasmania	500	20 ,,
New South Wales	454	18·3 ,,
South Australia	278	11·2 ,,
West Australia	243	9·8 ,,
Britain	766	30·9 ,,

It has to be noted here that these proportions do not by any means represent the true proportions in nature, but rather the amount of attention which has been given to the subject in the different Colonies. It is not to be imagined that the proportion of species in New South Wales is really less than that in Tasmania, or only 2½ times that of Victoria, but the explanation is to be sought in the fact that both Victoria and Queensland have been favoured in the past with indefatigable workers in this particular line. When I state that one-eighth of the entire Fungus-flora of New South Wales has been added during the last three years, it will be seen that the labours of such workers as Dr. Cobb, and Messrs. Maiden and Baker, are beginning to bear fruit in the much-neglected department of systematic mycology. Victoria has the highest percentage of species—or 46, closely followed by

Queensland, with about 44, while West Australia has the lowest with 9·8; 766 of the total number of species are British, or about 31 per cent. Now that the Agricultural Bureau of West Australia has a resident botanist in the person of Dr. A. Morrison, who has already done good work in the fungi of Victoria, we may shortly expect to have the numbers there largely increased.

GEOGRAPHICAL DISTRIBUTION.

While I have indicated how the fungi are numerically distributed in the different Colonies, I feel that the time has come when the geographical distribution within each Colony should be carried out in detail on a scientific basis. The Government Botanist of New South Wales, in his anniversary address before the Royal Society (1897), has already suggested the use of county maps and parish maps for recording the exact localities of economic plants; but we also require, as he has hinted, the different Colonies to be divided into well-defined geographical areas. Natural divisions based upon the drainage of the country, or other natural features, would take the place of merely arbitrary districts determined by the outlines of counties; and as these natural districts apply not only to the flora, but the fauna—would be, in fact, biological regions. I consider that such districts might best be settled for each colony by a joint committee of naturalists chosen by an association for the advancement of science such as this.

The number of genera in proportion to the species may also be taken into account as in the following table:—

Table IV.—Number of Genera in proportion to the Species in the different Colonies.

	Genera.	Species.	Proportion.
West Australia	126	243	51·8
South Australia	128	266	48·1
Tasmania	221	500	44·1
New South Wales	161	454	35·5
Victoria	304	1,142	26·6
Queensland	281	1,089	25·8
Australia	447	2,480	18

The number of genera in proportion to species is naturally larger in those colonies where the species are not yet extensively known, while for the whole of Australia the proportion is 18 per cent. The three genera which contain the most species are

Polyporus (94), Polystictus (93), and Fomes (57), but it must be borne in mind that the sub-genera of Agaricus, for instance, are raised to the rank of genera.

The edible fungi, especially our native species, have still to be tested in most cases. Mr. Maiden, in his presidential address before the chemistry section of this association, at Brisbane (1895), on "The Chemistry of the Australian Indigenous Vegetation," showed that our knowledge of the chemical composition of these plants is almost nil. I have mainly selected those which have been found wholesome in Britain or America, and which may be eaten with impunity, not necessarily with relish. The number at present is 84—73 belonging to the hymenomycetes, 4 to the gastromycetes, and 7 to the discomycetes. A list of Australian edible fungi is given as an appendix to my systematic arrangement.

If we compare the number of known Australian species with the British, as well as the total known number of fungi, an interesting result is obtained, as in the following table :—

Table V.—Number of Australian Species compared with British and Total known Species.

Groups.	No. of Australian Species (1897).	No. of British Species (1892).
1. Hymenomycetes	1,303	1,902
2. Gastromycetes	198	78
3. Uredines	112	53
4. Pyrenomycetes	285	
5. Discomycetes	140	1,275
6. Tuberoides	7	
7. Hyphomycetes	152	580
8. Sphaeropsides	152	685
9. Saccharomycetes	10	8
10. Ustilagines	48	177
11. Phycomycetes	21	145
12. Myxomycetes	52	137
Other groups	....	....
	2,480	5,040

The number of British species are taken chiefly from Massee's "British Fungus Flora," the most recent work on the subject and still in course of publication, but this only gives the approximate numbers up to 1892.

The total known species are given by Saccardo up to the end of 1896 as 44,963 or roughly 45,000; and the number of Australian species are given to the end of 1897, so that the comparison is not equal, but it is the best available.

The total number of known fungi is estimated at 45,000, and there are 2,480 Australian species, or about one-eighteenth of the whole, while there are 5,040 British species, or about one-ninth of the whole.

The proportion of Australian to British species is nearly one-half, and since 766 British species are common to Australia it is seen that over one-seventh are thus common to both countries.

The Australian Gastromycetes and Uredines far exceed the British, the former being in the proportion of 198 to 78, and the latter in the proportion of 112 to 53. The exceptional position of the Gastromycetes and Uredines is worthy of remark, and shows that these particular groups have a stronghold in Australia. It will be interesting to compare the species common to Victoria and Tasmania on account of their geographical proximity and their former land union.

The following table shows that out of a total of 500 Tasmanian species 197, or 39½ per cent. of the whole, are found in Victoria as well; and the percentage of species common to Victoria is 17·2 :—

Table VI.—Number of Tasmanian Species common to Victoria.

Group.	Victorian species.	Tasmanian species common to Victoria.	Percentage.
1. Hymenomycetes	603	99	16·4
2. Gastromycetes	72	15	20·8
3. Uredines	79	15	19
4. Pyrenomycetes	93	21	22·6
5. Discomycetes	71	20	28·1
6. Tuberoides	...	...	...
7. Hyphomycetes	80	12	15
8. Sphaeropsides	88	6	7
9. Saccharomycetes	...	...	...
10. Ustilagines	28	2	7·1
11. Phycomycetes	15	4	26·6
12. Myxomycetes	13	3	23
	1,142	197	17·2

SUMMARY.

Our knowledge of the Fungus-flora of Australia is too limited as yet to permit of general conclusions being drawn, and therefore I will content myself with giving a summary of the actual state of our present knowledge, as far as the present paper is concerned.

In Australia (including Tasmania) 12 groups of fungi are represented, containing 2,480 species, and of these 766 species are

common to Britain, or about 31 per cent. The largest number of recorded species are in Victoria, being 1,142, closely followed by Queensland, with 1,089, while New South Wales has only 454.

Of edible fungi the number is 84, belonging to the Hymenomycetes mainly ; but a few to the Gastromycetes and Discomycetes.

There are reckoned to be about 45,000 species of fungi altogether, and Australian species (2,480) form about one eighteenth of the whole, while British species (5,040) constitute about one-ninth of the whole.

And, finally, the number of Tasmanian species common to Victoria is 197, or 39½ per cent. of the entire Tasmanian Fungus-flora. . . . .

When we consider how favourable our climate is to the development of fungi, parasitic and otherwise, and particularly to the family of rusts which play such havoc at times with our cereal crops, it behoves us to pay more attention to them in the future than we have done in the past. Hitherto they have been treated more as an appendage than as an integral part of a Flora Australiensis, and while our neglected treasures of the vegetable kingdom claim our attention, let us not despise these so-called lower plants, for they are often a menace to our agricultural and horticultural prosperity, because we have so long neglected them.

No. 6.—UNDERGROUND FUNGI OF TASMANIA.

By L. Rodway, Hobart.

(*Read Tuesday, January* 11, 1898.)

The term underground, when applied to fungi, though not scientific, appeals sufficiently clearly to the student of mycology. All the terrestrial fungi, except moulds, might really be termed "underground"; but the sense in which it is used in mycology is to indicate fungi that habitually produce their spore-producing body beneath the surface, and either disintegrate there, depend for exposure on denudation, or the digging of fung loving animals.

The fungi that have this habit belong to two distinct groups, and appear to be confined to these. The one lot we meet with in the *Gasteromycetes*—that is, the family of which the puff-ball is the type—a group of the great sub-class *Basidiomycetes*. The other forms a group of itself, the *Tuberoides*, or Truffle group, in the big sub-class *Ascomycetes*.

Of the underground fungi belonging to the *Gasteromycetes*, the greater number form an order of their own—the *Hymenogastraceæ*, a very natural order of closely allied forms. Others, however, belong to the order *Lycoperdaceæ*—aberrant forms of great interest, as pointing out lines of descent. Those belonging to the *Tuberoides* have little in common; their relationship one to the other is distant.

Cooke, in his "Handbook of Australian Fungi," drew attention to the relatively large number of *Gasteromycetes* described in Australia, but observed a weakness in subterranean species. That this weakness was simply due to want of research I think this paper will amply prove. When the Handbook was published in 1892 there were twelve subterranean *Gasteromycetes*, ten of which belonged to the order *Hymenogastraceæ*, for the whole of Australia. Very little search, and that in three spots close to Hobart, has enabled me, within the last two years, to add to this eleven more, eight of which are new to science; in other words, in three small valleys I have found more species of *Hymenogastraceæ*, new at least to Australia, than had hitherto been described. We now stand in this position: In England, where there are something more than 4,900 described fungi, there are twenty-three *Hymenogasters*. In Australia there are eight to about 2,400 species, and in Tasmania we have already recorded no fewer than fourteen such plants in our small flora of about 550 species. The Australian and Tasmanian lists being compiled without the group having received reasonable attention, we can only conclude they will swell in the future to most surprising proportions. The following is a list of the fungi of purely subterranean habit that have, up to the present, been recorded in Tasmania. The new species, except *Stephensia varia*, have been described in the *Kew Bulletin* during the present year, but I am still uninformed of the date. The other new Australian forms are identified by Geo. Massee, but I have not received a record of their author's publication. *Stephensia varia* is described in the "Transactions of the Royal Society," Tasmania, December, 1897.

GASTEROMYCETES.

Octaviana archeri, Berk; *Hydnangium tasmanicum*, Kalch.; *H. australiense*, B. et Br.; *H. carneum*, Klot.; *Hysterangium affine*, Mass. et Rod.; *H. membranaceum*, Vitt.; *H. fusisporum*, Mass. et Rod.; *H. clathroides*, Vitt.; *H. viscidum*, Mass. et Rod.; *Gymnomyces pallidus*, Mass. et Rod.; *G. seminudus*, Mass. et Rod.; *Hymenogaster rodwayi*, Mass.; *H. violaceus*, Mass. et Rod.; *H. albellus*, Mass. et Rod; *Secotium rodwayi*, Mass.; *Diploderma glauca*, C. et M.; *Mesophellia arenaria*, Berk.

ASCOMYCETES.

Hydnocystis cyclospora, Mass. et Rod. ; *Stephensia varia*, Rod. ; *Genebea tasmanica*, Mass. et Rod. ; *Endogone australis*, Berk.

The solitary *Octaviana* has not been found, I believe, since its original discovery, and only very meagre material has existed, and that not available for local examination. There is no reason to infer the description is not accurate, so we may trust to meeting with it again. The large spores, if accurately measured, indicates its distinction from its allies. The sterile base in *Octaviana* appears to serve no useful purpose, and would apparently indicate descent from a stipitate sporocarp. *Hydnangium australiense* occupies a connecting position, and is often referred to *Octaviana*. In Tasmanian specimens the sterile base is obsolete or quite absent. There is one feature I have not seen noticed. The fungus, until past maturity, bears a copious latex of white milk. This plant, like the last, is generally met with lying free on the surface of the ground. How it gets there appears a mystery. It is not due, as in many similar cases, to denudation. Probably it is a result of low specific gravity and considerable shrinkage on loss of moisture. *H. carneum* is interesting from its wide distribution. It is the only underground fungus common to Tasmania and England. *H. tasmanicum* departs from the type in the cells, being very large and not very tortuous. They soon became filled with dark-brown spores, which on section gives the fungus a marbled appearance. *Hydnangium* only differs from *Octaviana* artificially, namely, in the absence of a sterile base.

The genus *Hysterangium* differs from adjoining forms by the gleba being at first gelatinous, and becoming almost cartilaginous ; but in most Tasmanian forms it appears to remain permanently of a gelatinous or waxy consistency. As the fungus matures, the tortuous hymenial canals develop, and more or less obliterate the trama. In *H. fusisporum* and *H. membranaceum* the canals are very numerous, tortuous, and closely packed. In *H. viscidium* and *H. clathroides*, on the contrary, the trama remains abundant. *H. affine* is a pretty and common little fungus that, from its free distribution throughout Tasmania, would lead one to expect its existence on the mainland. *H. membranaceum* is small and delicately white, and becomes blotched with indigo wherever bruised. *H. fusisporum* is very close to *Hymenogaster albellus*, and, like it, possesses bisporous basidia. It forms a distinct link between the genera. Tasmania is evidently very rich in this genus, for, besides the five here referred to, I know of three not yet determined. The mainland does not yet boast a single species, and in the large fungus flora of England we find but two. The genus *Gymnomyces* we founded upon two species, to which I drew Mr. Massee's attention. The marked peculiarity is the almost or

quite absence of a peridium. *G. pallidus* is a fairly large plant for the order—up to 3·4 cm. diameter. The peridium appears quite absent, and the gleba, with its copious development of minute tortuous canals, appears like a fungus stripped of its skin. There is often an indication of a sterile base, and in one plant I found growing from a depression in the base a minute slender stem about 7 mm. long. There was a total absence of column running through the gleba ; but one could not fail to imagine a distant relationship to *Secotium*. *G. seminudus* has a thin, but evident inseparable, skin, and appears to have lost even the semblance of a stem.

Among our *Hymenogasters*, which are all three new, there is much room for reflection. *H. albellus* is pronouncedly subterranean, with a very small sterile base, and, like its nearest neighbour, its basidia are bisforous. *H. rodwayi* has a fairly developed sterile base, with radiating arms running towards the apex. *H. violaceus*, on the contrary, can hardly be said to be subterranean, always becoming exposed on maturity. The base is well developed, and in many specimens sends a process right through to the apex, suggesting a close relationship to *Secotium*.

In *Lycoperdaceæ* the genus *Secotium* consists of plants standing in the direct line of descent between *Hymenogasters* and *Agarics*. Typically they are above-ground fungi, have a well-developed stem, a persistent trama, and permit an escape of spores by the peridium bursting from the stem at the base. In Tasmania we have two plants that stand as near the confines of the genus as possible. *S. gunnii*, Berk., is rather variable. In one extreme it has a well-developed stem, whose substance expands above to partially form the flesh of a pileus. The lower edge of the peridium is quite free, and connected with the stem by an arachnoid veil, while the tubes, though still contorted, are roughly arranged at right-angles to the margin, so that they assume the appearance of deformed gills. In this extreme form *S. gunnii* could easily, and indeed often is, mistaken for a deformed brown spored *Agaric*. In the further extreme the stem barely pierces to the apex, the base is sunk round the stem, and the tubes are much convoluted. *Secotium rodwayi* departs from the habit of the genus in being completely subterranean unless or until accidentally exposed. It has in the normal state a fairly thick but very short stem which pierces to the apex and a deeply indented base. The spores are globose, nearly smooth, and colourless ; but for this it might be taken for a *Hymenogaster* with an abnormally developed stem. The presence of a well-developed but apparently useless stem in this species, and the existence of rudimentary homologous members in so many of the *Hymenogasters*, would possibly indicate, contrary to generally received doctrines, a descent of *Hymenogasters* from *Agarics*.

Diploderma glauca appears to have been responsible for some confusion requiring elucidation. The typical form of the genus, according to Cooke, is that figured by him as being this species in his Australian Handbook, namely, two peridia, a central sterile body, and intervening gleba, which disintegrates into a loose mass of spores and fibres. This species was described by Cooke in conjunction with Massee; so, in order to be sure of my position, I submitted specimens to Mr. Massee for identification. The plant, which is very common in certain localities, possesses no central sterile body at all. The outer peridium is coarsely fibrous, the inner one thin, hard, and brittle, and the gleba on maturity is disintegrated, and consists of a floccosse mass of spores with shrivelled cells, and very few fibres, if any. The plant frequents places where there is a liability to disturbance. Upon denudation the inner peridium is washed out, and like a light ball is carried about on flood-waters. If the peridium is not now fractured, it subsequently bursts at the point subjected to greatest desiccation in a roughly stellate form. The plant does not seem to be sought after by animals.

Mesophellia arenaria, on the contrary, appears to depend for dispersion on animal agency. It is much prized by lesser marsupials, who appear to smell its presence with accuracy. They unearth it, tear it open, eat the central core, and leave the dusty mass of spores and delicate fibres at the mercy of the winds. Judging from analogy, through *Csycloderma* we can only conclude the central body is an ultimate remnant of an ancestral stem.

The underground *Ascomycetes* of Tasmania are few, and have little in common. Each appears a solitary form, whose relations are in distant parts. *Hydnocystis cyclospora* is identical with the plant described by Mr. McAlpine and myself in the *Agricultural Gazette*, New South Wales, February, 1896, as *H. convoluta*. Mr. Massee subsequently writes: "Your *Hydnocystis convoluta* is absolutely identical with the type specimen of *Berggrenia aurantiaca*, var. *cyclospora*, Cooke. It is difficult to know why Cooke made a globose spored species a variety of an elliptical spored species. The two are distinct. Then, again, Cooke's genus *Berggrenia* is not distinct from *Hydnocystis*." *Hydnocystis* is of interest to the student. It is barely, or not always, subterranean. Its free and continuous hymenium shows a close relationship to the *Discomycetes*. *Stephensia varia*, truly underground, but often exposed by denudation, has only one other relative in Australia, *S. arenivaga*, C. et M., from Central Australia. It either is very variable in development, or there are at least three closely allied forms. The type is 3–4 c. m. diameter, with a cartilaginous peridium, a copious byssoid-pithy trama, and few rather large convoluted tubes. But there is one form rather larger in habit, where

the trama is almost absent, and the tubes very numerous, and another small form with copious, more delicate, trama, and a single more or less convoluted sack. This latter form is often found lying on the surface, with the peridium alone left, the trama and hymenium being both consumed by insects. The asci and spores are the same in all three forms.

Genebea tasmanica is a medium-sized rather fleshy tuber, with a white fleshy gleba, in which hyaline patches occur. In these patches are developed pyriform asci, each containing four oblong shining black spores.

Endogone australis I am unacquainted with, and it appears still to be in that most unsatisfactory position of possessing a name without a definition.

No. 7.—THE ALGAE OF VICTORIA.

By Henry Thos. Tisdall, F.L.S.

(*Read Tuesday, January* 11, 1898.)

The south coast of Victoria is washed for nearly its whole extent by the waters of Bass' Straits, and it may be presumed that it is mainly owing to this, that under certain circumstances such enormous quantities of sea-drift are thrown on our shores. One instance will be sufficient to illustrate this. In January, 1897, the weather was very unsettled, and on the morning after a strong gale from the south-west, the writer of this paper found the whole shore, from Barwon Estuary away towards Port Lonsdale, covered with a mass of sea-drift varing from 1 to 3 feet high.

The main current in Bass Straits comes from the Pacific Ocean, but every island, rock, or headland turns some of its waters in a different, often an opposite, direction. As a matter of fact there was a strong westerly current on that day along the coast of Ocean Grove from Barwon Heads towards Point Lonsdale. The mass of seaweeds was composed of hundreds of different species, brown, green, and red, all mixed and churned into inextricable confusion. It is a pity that the wealth thus thrown up by the sea should not be utilised. In other countries hundreds of men, women, and children would have rescued thousands of tons of this valuable manure, thus enriching the soil in the neighbourhood.

But no one interfered, and after a couple of tides the whole was gradually sucked back by the retiring waters, and the beach for miles presented an unbroken surface of sand, save a slight margin

of drift marking the highest flow of the tide. As before mentioned, a great number of species were to be seen in this drift. The great size of the brown seaweeds made that colour dominate the whole. Notably were to be seen the great leathern fronds of *Durvillea*, which had been so firmly fastened to the rocks that the schizoids were still firmly clasped around small masses of stone.

Different species of *Sargassum* and *Cystophora* were very common; *Ecklonia*, *Carpomitra*, and *Sporochnus* were mixed up with the huge fronds of *Macrocystis*, and the necklace-like bladders of *Hormosiræ*. This *Macrocystis* is the same species that Darwin gives such a vivid description of in his "Voyage of the Beagle." He mentions that many shipwrecks have been averted by their presence on the surface of the sea indicating hidden shoals. He speaks of them as completely covering all the rocks that are partly or wholly submerged. In Harvey's "Phy. Australis," vol. iv, *Macrocystis pyrifera* is thus described: "The cord-like stems, when the plant grows in deep water, have been estimated variously at 500 to 1,500 feet. At whatever depth the plants vegetate the stem rises at a considerable divergence from the perpendicular to the surface, where their leaves are buoyed up by their vesicles." It is further stated that "it is only the terminal leaf which must be regarded as a modification of a bud which develops new leaves by splitting; the lateral leaves once formed remain unchanged till they decay." Thus we remark that this is undoubtedly the longest plant in the world. But returning to our sea-drift, the flat olive-green fronds of *Haliseris* were to be seen in every heap. The red seaweeds were also well represented. A few broken specimens of the loveliest of all seaweeds, *Claudea elegans*, could be found occasionally.

As *Claudea elegans*, as far as is known, flourishes only in the estuary of the Tamar, on the opposite coast of Tasmania, it shows that the current which, coming from the west, bore these specimens to Ocean Grove, must at one time have passed the mouth of the Tamar. The larger species of *Griffithsia ceramium*, *Halymena rhodymenia*, &c., might be seen in hundreds, while the smaller species of *Callithamnion*, *Polysiphonia*, &c., might be obtained on the larger types of seaweed. The *Chlorophyceæ* were also well represented, *Caulerpas*, *Codium*, *Vaucherias*, and *Ulvas*, with their bright green fronds, glistened on every side. Amongst the light-coloured or yellowish-red species were an immense number of *Gelidium*. In the Melbourne Botanic Museum one of these *Gelidiums* was marked as edible, and Shirley Hibberd, in his work entitled "The Sea-weed Collector," says "that the birds-nests weed (*Gelidium*) of China and Japan is collected by swallows for the construction of their nests." It is well known that these nests are of great commercial value, and it would be well worth experimenting on some of these species of seaweed to see if it could not be utilised in some

way. Another order of *Algæ* that is much used in Western Europe as food was well represented in the seadrift, namely, *Ulvaceæ*. One of these, *Posphyra vulgaris* (or purple laver), is exactly the same species that is used so much on the west coasts of Ireland and England on account of its gelatinous character, and "those who have acquired a taste for it," says Shirley Hibberd, "declare it to be delicious, especially when served with lemon juice."

This *Posphyra vulgaris* was lying in great quantities on the shore, along with a green variety, *Ulva latissima*. This last-mentioned seaweed is also prepared and eaten in the same way as *P. vulgaris*. It would be useless to go through the list of species noted on that memorable morning; indeed the writer was fortunate enough to be present on several similar occasions, and was thus enabled to secure an immense number of specimens with comparative ease.

On the west side of the Western Port Heads there is a long narrow peninsula called Flinders, bounded on one side by Western Port Bay, and on the other by Bass Straits; it ends in what is called West Head. This is a happy hunting-ground for a seaweed collector. On the Straits side, when the tide is out, may be found the seaweeds in their natural home, fastened to the rocks, either in basins or pools left by the returning tide, or high and almost dry under the fierce rays of the summer sun. It is interesting to watch the incoming tide rushing over the apparently dying plants. At first a languid movement may be observed, getting more natural with every succeeding wave, until by the time they are completely submerged the plants are as bright in their appearance and as graceful in their movements as if they had never been uncovered. The green hair-like tufts of *Cladophora*, *Chætophora*, and *Enteromorpha*, the bright green membraneous *Ulva*, and here and there the delicate feathery *Bryopsis plumosa* may be seen lining the sides of the pools. Everywhere is to be found *Hormosira Banksii*—in fact you must tread on their elastic bladders as you step from rock to rock. *Cystophora* are also very plentiful. Under the larger olive and brown seaweeds *Polysiphonias*, *Ceramiurnus* and *Laurentias* may be seen with their red fronds glittering in the sunlight. Two *Zosterias* are so common in the shallow pools as to be especially noticeable, namely, *Zos. tasmanica*, with its grass-like leaves often entirely covering the sandy bottom, and *Cymodacea zosterifolia*, which is sometimes seen growing in the sandy bottoms of pools, whence it is easily extracted, and its long creeping rhizomes can be examined; but it often grows on the rocky sides, from whence it is almost impossible to move it without destroying it. Although these plants are true phanerogams in their structure and mode of reproduction, still their constant occurrence in our tide pools requires them to be mentioned. Again, on the long stems of *Cymodacea* which often attain a length of from 12 to 20 feet, may

be found an immense number of parasitic seaweeds. These parasites only grow from the nodes of the plant, and it is really very interesting to note the tiny parasites forming a complete fringe around each node. As a general rule each node bears a fringe of the same species, but sometimes two or even more separate kinds may be counted at the same node. At the other side of Flinders Peninsula, Western Port stretches away northward, and a different class of seaweed may be found growing on the low rocks and boulders left uncovered. The more delicate of the *Callithamnion*, *Areschougiæ*, *Horeas*, and *Mychodeas* flourish in these peaceful pools ; also, after heavy weather a fine harvest may be obtained from the sea drift. A strong current comes in from Bass' Straits, along the coast of Wilson's Promontory, and so flows into Western Port on the west of Phillip Island. From this circumstance it may be presumed is due the fact that different species of seaweed are found in Western Port that are not found in other parts of Victoria. Further westward, along the coast is Cape Schanck, on whose weather-beaten rocks the number of seaweeds to be found is much smaller, but they are very interesting. In the basins left at ebb tide the writer found no less than seven different species of *Zonaria*, also the pretty little *Padina pavonia*, their delicate fan-like structures springing horizontally from the almost vertical sides of the basin. Again, on the outside rocks, deep below the water, may be seen the huge fronds of *Durvellia potatorum*. These plants are firmly fastened to the rocks by a thick scutate disc, often 6 inches in diameter, and fully 1 inch thick ; the short, thick stem gradually flattens and widens out into broad, brown, leather-like fronds, not unlike a blacksmith's apron, but much thicker. As the rocks on which they grow are constantly washed by the fierce flow of either the receding or incoming tides, the strain on the plants must be enormous, and as one looks and sees them on a lovely calm afternoon dashing first one way and then another, and lashing the rocks every time, one cannot help wondering at the immense inherent strength required to live through a heavy storm. At Sorrento a decided change in the species of seaweed may be noticed. Besides those already mentioned numbers of specimens of *Plocamium*, *Gigartina*, and *Wrangelia* may be obtained. Here also may be found several kinds of *Corallincea*. These plants being generally incrusted with lime are very brittle, and require careful handling, particularly *Amphiroa* and *Fania*. The species of Algae found at or near Port Philip Heads will be found very carefully compiled by the late M. J. Bracebridge Wilson, of Geelong, in "Proceedings of the Royal Society of Victoria," vol. iv. He gives a full description of where he dredged, and found the different species mentioned.

More than this he presented a magnificent collection of dried and mounted specimens to the Botanic Museum of Melbourne

On each specimen sheet is noted the exact channel or distance from the shore, depth of water, and in fact every particular that may be of use to the student who wishes to work up the algae of Port Philip Heads. The description of a number of algae new to science (at that time) found by Mr. Wilson, and named by J. G. Agardh, may be seen in the report of the A.A.A.S., vol. ii, 1890. To the west of Port Philip Heads are a number of seaside resorts that are particularly rich in seaweeds. Ocean Grove has been already noticed with reference to its seadrift. But the rocks uncovered at ebb tide are well worth examining in this neighbourhood. The curious *Codium bursa* is only found fastened to the base of rocks that are last uncovered and first covered, so that it is always in deep water. The next place is Barwon Heads, then Bream Creek, and Spring Creek (Torquay). It will be unnecessary to detail the seaweeds found at these places as I have specially noticed the locality of each species in the list appended to this paper. This is the first complete list of Victorian algae, and in compiling it I was helped in the most material way by several gentlemen. Mr. J. Gabriel placed at my disposal his magnificent collection of Victorian algae. These were collected at Warrnambool and elsewhere by the late Mr. Henry Watts, a most indefatiguable worker in natural history. I am also deeply indebted to Mr. J. G. Luehmann, Curator of the Botanic Museum, for the courtesy and actual help always forthcoming when required.

LIST OF VICTORIAN ALGAE TO DECEMBER, 1897.

By Henry Thos. Tisdall.

I. Fucoideæ (Melanospermeæ).

Fucaceæ.

Sargassum, Ag. Harv. Phy., Aus., vol. ii, pl. 110 ; iii, pl. 145 ; iv, pl. 208.
S. linearifolium, Ag. Bream Creek.
muriculatum, J. Ag. Bream Creek.
sonderi, J. Ag. Cape Schank.
verrucolosum, J. Ag. Point Lonsdale.
cristatum, J. Ag. Port Phillip Heads.
gunnianum, J. Ag. Port Phillip Heads.
varians, Sond. Port Phillip Heads.
leptopodum, J. Ag. Ocean Grove.
lævigatum, J. Ag. Ocean Grove.
Raoullii, J. Ag. Ocean Grove.
lopocarpum, J. Ag. Ocean Grove.
phyllanthus, J. Ag. Ocean Grove.
bracteolorum, J. Ag. Ocean Grove.
critida, J. Ag. Ocean Grove.
trichophyllum, J. Ag. Ocean Grove.
fallax, Sond. Sorrento.
paradoxum, Ag. Wilson's Promontory.

S. undulatum, J. Ag. Port Phillip.
biforme, Sond. Point Lonsdale.
vestitum, R. Br. Barwon Heads.
teretifolium, J. Ag. Port Phillip Heads.
spinuligerum, Sond. Port Phillip.

Seirococcus, Grev.

S. axillaris, Grev. Bream Creek, Harv. Phy. Aus., vol. i, pl. 4.

Carpophyllum, Grev.

C. phyllanthus, Grev. Port Phillip.
muricatum, J. Ag. Barwon Heads.

Scytothalia, Grev.

S. dorycarpa, Grev. Port Fairy, Harv. Phy. Aus., vol. i, pl. 9.

Phyllospora, Ag.

P. comosa, Ag. Ocean Grove.

Scaberia, Ag.

S. Agardhii, Grev. Werribee Jetty, Harv. Phy. Aus., vol. iii, pl. 164.

Caulocystis, Aresch.

O. cephalornthos, Aresch. Sorrento.
uvifera, Aresch. Ocean Grove.
brevifolia, Sond. Port Phillip.

Cystophora, J. Ag.

C. platylobium, Ag. Sorrento.
racemosa, Harv. Sorrento.
retorta, J. Ag. Ocean Grove.
retroflexa, J. Ag. Ocean Grove.
siliquosa, J. Ag. Sorrento.
torulosa, J. Ag. Western Port, Harv. Phy. Aus., vol. iii, pl. 123.
botryocystis, Sond. Port Phillip, Harv. Phy. Aus., vol. i, pl. 56.
Grevillei, J. Ag. Point Lonsdale, Harv. Phy. Aus., vol. iv, pl. 183.
spartioides, J. Ag. Point Lonsdale, Harv. Phy. Aus., vol. ii, pl. 76.
monilifera, J. Ag. Sorrento, Harv. Phy. Aus., vol. v, pl. 245.
sub-farcinata, Ag. Western Port.
laxa, Sond. Port Phillip.
polycystidea, Aresch. Port Phillip.
cephalornthos, J. Ag. West Head, Western Port, Harv. Phy. Aus., vol. ii, pl, 116.
uvifera, J. Ag. West Head, Harv. Phy. Aus., vol. iii, pl. 175.
camphylocoma, J. Ag. West Head.
mucronmera, J. Ag. Barwon Head.
Sonderi, J. Ag. Ocean Grove, Harv. Phy. Aus., vol. v, 243.
paniculata Aresch. Point Lonsdale, Harv. Phy. Aus., vol. v, pl. 247.

Cystophyllum, J. Ag.

C. muricatum, J. Ag. Ocean Grove, Harv. Phy. Aus., vol. iii, pl. 139.

Fucodium, J. Ag. Harv. Phy. Aus., vol. i, pl. 53.

F. chondrophyllum, J. Ag. Ocean Grove.

Hormosira, Endl.

H. Banksii, Decaisne. Point Lonsdale, Harv. Phy. Aus., vol. iii, pi. 135.

Carpoglossum, Kuetz.

C. confluens, J. Ag. West Head, Harv. Phy. Aus., vol. iii, pl. 159.

Myriodesma, Decaisne. Harv., Phy. Aus., vol. iv, pl. 219.

M. integrifolium, Harv. West Head.
quercifolium, Sond. Point Lonsdale.
pinnatifidum, J. Ag. Barwon Heads.
calophyllum, J. Ag. Ocean Grove.

Durvillæa, Bony.

D. potatorum, Aresch. Cape Schanck, Harv., Aus., vol. v, pl. 300.

Splachnidium, Grev.

S. rugosum, Grev. Red Bluff, Port Phillip Bay, Harv. Phy. Aus., vol. i, pl. 14.

Notheia, Bail and Har.

N. anomala, B. and H. Port Lonsdale, Harv. Phy. Aus., vol. iv, pl. 213.

Sporochnaceæ.

Carpomitra, Kuetz.

C. cabreræ, Kuetz. West Head.
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obscurum, J. Ag. Flinders.
Gattyanum, J. Ag. Cape Schanck.
Gunnianum, Harv. Ocean Grove, Harv. Phy. Aus., vol. v, pl. 241.
affine Harv., Harv. Bream Creek.
multipartitum, Hook. Sealer's Cove.
parvifolium, J. Ag. Port Phillip Bay.
Curdieanum, Harv. Point Lonsdale, Harv. P. A., vol. iii, pl. 151.
erosum, Harv. Cape Schanck, Harv. P. A., vol. i, pl. 94.
pristoidum, Harv. Queenscliff, Harv. Phy. Aus., vol. iv, pl. 229.
endiviœfolum, Hook. Point Lonsdale.
polyanthum, J. Ag. Sorrento.
uncenatum, J. Ag. Sorrento.
monanthos, J. Ag. Western Port.
fallax, J. Ag. Ocean Grove.
subfalvum, J. Ag. Sorrento.
heterocyatidea, Sond., Warrnambool.
Delesseria, Grev., Harv. P. Aus., Plates 87, 137, 150, 244, 59, 268.
frondosa, Harv. Ocean Grove, Harv. Phy. Aus., vol. ii, pl. 179.
simulans, J. Ag. Flinders.
revoluta, Harv. Ocean Grove, Harv. Phy. Aus., vol. iii, pl. 170.
tasmanica, F. Müller. Western Port.
imbricata, Aresch. Flinders.
heterocystidea, J. Ag. Point Lonsdale.
marginifera, J. Ag. Sorrento.
endiveæfolia, J. Ag. Sorrento.

Caloglossa, Harv.

C. Leprieurii, Harv. Port Fairy.

Helminthocladieæ.

Helminthocladia, J. Ag.

H. australis, Harv. Port Phillip Heads, Harv. Phy. Aus., vol. v, pl. 272.

Helminthora, J. Ag.

H. divaricata, J. Ag. Ocean Grove.

Nemalion, Duby.

N. insigne, Harv. Port Phillip Heads, Harv. Phy. Aus., vol. v, pl. 284.

Glocophloca, J. Ag.

G. scinaroides, J. Ag. Western Port.

Scinara, Bivona.

S. furcellata, Biv. Ocean Grove.
moniliformus, J. Ag. Ocean Grove.

Tiarophora.

T. australis, J. Ag. Port Phillip Heads.

Liagora, Lamx., Har. Phy. Aus., pl. 162.

L. viscida, Ag. Sorrento, Har.
australasica, Sond. Port Phillip Heads.

Galaxaura, Lam., Har. Phy. Aus., plates 275, 228.

G. marginata, Lamour. Ocean Grove, Har. Phy. Aus., vol. iii, pl. 136. sub nom Lanardinia marginata.

Chætangieæ.

Zanardinia, J. Ag.

Z. marginata, J. Ag. Western Port.

Bindera, Harv.

B. splachnoides, Harv. Ocean Grove.

Chætanguim, Kuetz.

C. variolosum, J. Ag. Port Phillip.

Acrotylus, J. Ag.

A. australis, J. Ag. Western Port.

Gelidieæ.

Pterocladia, J. Ag.

P. lucida, J. Ag. Western Port, Harv. Phy. Aus., vol. v, pl. 248.

Gelidium, Lamx.

G. acrocarpum, Harv. Port Fairy.
corneum, Grev. Ocean Grove.
asperum, Harv. Ocean Grove.
glandufolium, Hook. Flinders. Harv. Phy. Aus., vol. i, pl. 10.
proliferum, Harv. Cape Schanck.
australe, J. Ag. Western Port.

Hypneaceæ.

Gattya, Harv.

G. pinnella, Harv. Western Port, Harv. Phy. Aus., vol. ii, pl. 93.

Hypnea, Lam.

H. musciformes, J. Ag. Ocean Grove.
episcopalis, Hook. Flinders, Harv. Phy. Aus., vol. i, pl. 23.
ramentacea, J. Ag. Flinders.
seticulosa, J. Ag. Port Phillip Heads.
reticulata, J. Ag. Point Lonsdale.
australis, J. Ag. Port Phillip Heads.

Merrifieldia, J. Ag.

M. ramentacea, J. Ag. Port Phillip Heads.

Dasyphlæa, Mont.

D. insignis, Mont. Ocean Grove.
tasmanica, J. Ag. Barwon Heads, Harv. Phy. Aus., vol. ii, pl. 115.

Mychodea, Harv.

M. terminalis, Harv. Cape Schanck, Harv. Phy. Aus. vol. iv, pl. 200.
longipes, Sond. Port Phillip.
membranacea, Harv. Ocean Grove.
carnosa, Harv. West Head, Harv. Phy. Aus., vol. iii, pl. 142.
pusilla, Harv. Queenscliffe.
fastigata, Harv. Point Lonsdale.
Laurata, Harv. Ocean Grove.
compressa, Harv. Western Point, Harv. Phy., Aus., vol. iv, pl. 201.
foliosa, Harv. Cape Schanck.
decipiens, J. Ag. Port Phillip Heads.

Ectoclinum, J. Ag.

E. dentatum, J. Ag. Ocean Grove.

Solierieæ.

Gelinaria, Sond. Harv. Phy. Aus., vol. ii, plate 85.
G. Harveyana, J. Ag. Ocean Grove.
marginata, J. Ag. Western Port.

Rhabdonia, Harv. Phy. Aus., plates 152, 299.

R. nigrescens, Harv. Ocean Grove.
coccinea, Harv. Brighton Beach, Harv. Phy. Aus., vol. i, pl. 54.
dendroides, Harv. Cape Schanck, Harv. Phy. Aus., vol. iii, pl. 166.
robusta, Grev. Ocean Grove.
mollis, Harv. Sorrento.
hamata, Harv. Port Phillip.
charoides, Harv. Western Port, Harv. Phy. Aus., vol. iv, pl. 196.
clavigera, J. Ag. Western Port.
verticillata, Harv. Ocean Grove.

Soliera, J. Ag.

S. australis, J. Ag. Western Port.

Eucheuma, J. Ag.

E. speciosum, Sond. Port Fairy.

Wrangelieæ.

Monospora, Solier.

M. australis, Harv. Mouth of Snowy River.
gracilis, Harv. Point Lonsdale.

Bornetea, Thuret.

B. Meredithiana, J. Ag. Ocean Grove.

Wrangelia, Ag. Harv. P. Aus., pl. 233.

W. nitella, Harv. Western Port, Harv. Phy. Aus., vol. ii, pl. 105.
mucronata, Harv. Port Phillip Heads.
myriophylloides, Harv. Barwon Heads, Harv. Phy. Aus., vol. iv, pl. 224.
velutina, Harv. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 46.
protensa, Harv. Ocean Grove.
Halurus, Harv. Western Port, Harv. Phy. Aus., vol. ii, pl. 70.
verticillata, Harv. Point Lonsdale.
crassa, Hook. Torquay.
Wattsii, Harv. Torquay.
clavigera, Harv. Barwon Heads, Harv. Phy. Aus., vol. v, pl. 287.
ballioides, J. Ag. Point Lonsdale.
nobilis, Harv. Sorrento.
setigera, Harv. Ocean Grove.
plumosa, Harv. Ocean Grove.
princeps, Harv. Ocean Grove, Harv. Phy. Aus., vol. iv, page 234.
incurva, J. Ag. Western Port.

Chondrieæ.

Cœloclonum, J. Ag.

C. verticillatum, Harv. Port Phillip Heads.
opuntioides, Harv. Ocean Grove.

Corynecladia, J. Ag.

australasica, Sond. Wilson's Promontory.
umbellata, J. Ag. Ocean Grove.

Laurencia, Lamoux

L. Fosteri, Grev. Ocean Grove.
arbuscula, Sond. Barwon Head.
dendroidea, J. Ag. Point Lonsdale.
heterocladia, J. Ag. Western Port, Harv. Phy. Aus., vol. iii, pl. 148.
botryoides, J. Ag. Warrnambool, Harv. Phy. Aus., vol. iv, pl. 142.
crusiata, Harv. Western Port.
obtusa, Lam. Wilson's Promontory.
elata, Harv. Torquay.
Grevilleana, Harv. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 15.
divaricata, J. Ag. Ocean Grove.

Chondria. Harv. Phy. Aus., plates 189, 239, 102, 147, 280.

C. spuntiodes, Sond. Point Lonsdale.
corynophora, J. Ag. Ocean Grove.
dasyphylla, J. Ag. Ocean Grove.
curdeana, J. Ag. Sorrento.

Asparagopsis, Mont. Harv. Phy. Aus., plate 6.

A. armata, Harv. Warrnambool, Harv. Phy. Aus., vol. iv, pl. 192.
delilei, Harv. Port Phillip Heads.

Delisea, Lamx.

D. elegans, Ag. Ocean Grove.
hypneoides, Harv. Ocean Grove, Harv. Phy. Aus., vol. iii, pl. 134.
pulchra, Grev. Sorrento, Har. Phy. Aus., vol. i, pl. 16.

Bonnemaisonia, J. Ag.

B. asparagoides, J. Ag. Port Phillip Heads.

Ptilonia, J. Ag.

P. australasica, Harv. Port Fairy.
subulifera, J. Ag. Port Phillip Heads.

Leptophyllis, J. Ag.

L. conferta, J. Ag. Ocean Grove.

Halitania, J. Ag.

H. Wilsonis, J. Ag. Port Phillip Heads.

Rhodomeleæ.

Claudea, Lamx. Harv. P. A., plate 61.

C. elegans, Lamx. Western Port, Harv. Phy. Aus., vol. i, plate 1.
sunpliscanta, Harv. Port Fairy.
periclada, Harv. Port Fairy.

Martensia, Hering. Harv. P. A., page 127.

M. australis, Harv. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 8.
elegans, Hering. Ocean Grove.

Dictyurus, Bery., Harv. Phy. Aus., plates.

D. australis, Sond. Western Port.
quercifolius, J. Ag. Cape Schanck.
teres, J. Ag. Port Phillip Heads.
gymnopus, J. Ag. Point Lonsdale.

Hanowia, Sond.

H. robusta, Harv. Western Point.
arachnoidea, Harv. West Head.

Cliftonia.

C. pectinata, Harv. Ocean Grove., Harv. Phy. Aus., vol. ii, pl. 100.

Amansia, Lamour. Harv. Phy. Aus., plates 51, 222.

A. linearis, Harv. Point Lonsdale, Harv. Phy. Aus., vol. ii, p. 108.
similis, Harv. Warrnambool.

Polyzonia, Suhr.

P. Sonderi, Harv. Western Port.
encisa, J. Ag. Ocean Grove.
flaccida, Harv. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 42.

Lenormandia, Sond. Harv. Phy. Aus., pl. 181.

L. Muelleri, Sond. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 45.
marginata, Harv. Ocean Grove, Harv. Phy. Aus., vol. iv, pl. 235.
prolifera, J. Chauvenir, Harv. Port Phillip Heads, N.P.
Grevilleana, J. Ag. Bream Creek.

Polyphacum, Ag.

P. Smithiæ, Harv West Head.

Ieannerettia, Harv.

I. lobata, Hook. Point Lonsdale, Harv. Phy. Aus., vol. i, pl. 33.

Melanoseris, Zan.

M. crispata, Zan. Port Phillip Heads.

Pollexfenia, Harv.

P. pedicellata, Harv. Ocean Grove.
crenata, J. Ag. Western Port.
nana, J. Ag. Ocean Grove.
crispata, J. Ag. Ocean Grove.

Sarcomenia, Sond. Harv. Phy. Aus., pl. 12.

S. delesserioides, Sond. Ocean Grove, Harv. Phy. Aus., vol. iii, pl. 121.
tenera, J. Ag. Bream Creek.
dasyoides, Harv. Western Port.
Victoria, J. Ag. Barwon Heads.
mutabilis, J. Ag. Ocean Grove.

Acanthophora, Lamx.

A. arborea, Harvey. Port Phillip Heads.
Thierii, Lam. Ocean Grove.

Dictyminia, Grev. Harv. Phy. Aus., plates 21, 124.

D. tridens, Grev. Sorrento.
Harveyana, Sond. Cape Schanck.

Trigenia, Sond.

T. australis, Sond. Port Phillip Heads.

Rhodomelia, Ag., Harv. P. A., vol. iii, pl. 130.

R. periclada, Sond. Brighton, Harv. Phy. Aus., vol. i, pl. 28.
Preissii, Sond. Ocean Grove.
simplicicaulis. Western Port.
trigena. Warrnambool, Harv. Phy. Aus., vol. iii, pl. 126.

Rytiphlœa, Sond.

R. australasica, Mart. Ocean Grove, Harv. Phy. Aus., vol. i, pl. 27.
elata, Harv., Sond. Ocean Grove, Harv. Phy. Aus., vol. iv, pl. 239.
simplicifolia, J. Ag. Western Port, Harv. Phy. Aus., vol. v, pl. 246.
umbellata, J. Ag. Point Lonsdale.

Alsidium, Ag.

A. comosum, Harv. Port Phillip Heads.

Chondriopsis, J. Ag.

C. ovalifolia, J. Ag. Port Phillip Heads.
Harveyana, J. Ag. Ocean Grove.
dasyphilla, J. Ag. Port Fairy.
fustifolia, J. Ag. Ocean Grove.

C. debilis, J. Ag. Ocean Grove.
arborescens, J. Ag. Barwon Heads.
succulenta, J. Ag. Barwon Heads.
corallorhiza, J. Ag. Bream Creek.
foliifera, J. Ag. Point Lonsdale.

Bostrychia, Mont. Harv. P. Aus., Pl., 176.

B. uvularis, Harv. Point Lonsdale, Harv. Phy. Aus., vol. iii, pl. 176.
Harveyi, Mont. Ocean Grove, Harv. Phy. Aus., vol. iv, pl. 292.
acicarpa, Harv. Ocean Grove.

Polysiphonia, Grev. Harv. Phy. Aus., Plates 35, 96, 185, 185.

P. Hookeri, Harv. Ocean Grove.
mallardiæ, Harv. Western Port.
Hystrix, Harv. Western Port.
abscissa, Hook. Ocean Grove.
laxa, Harv. Point Lonsdale.
succulenta, Harv. Port Phillip.
Blandi, Harv. Flinders, Harv. Phy. Aus., vol. iv, pl. 184.
mollis, Harv. Flinders.
rufo-lanosa, Harv. Ocean Grove.
australis, J. Ag. Ocean Grove.
sphacelarioides, J. Ag. Western Port.
Gunniana, J. Ag. Western Port.
spinosissima, Harv. Ocean Grove.
succulenta, Harv. Port Phillip Heads.
cladostephus, Mont. Ocean Grove.
dendritica, Ag. Ocean Grove.
pinnata, Ag. Port Phillip Heads.
versicolor, Hook. Ocean Grove.
rostrata, Sond. Flinders, Harv. Phy. Aus., vol. v, pl. 242.
pectinella, Harv. Bream Creek.
tasmanica, Sond. Bream Creek.
nigrita, Sond. Barwon Heads.
cancellata, Harv. Flinders.
frutex, Harv. Ocean Grove.
fuscescens, Harv. Ocean Grove.
Patersonii, Sond. Port Fairy.
cæspitula, Sond. Point Lonsdale.
amæna, Sond. Cape Schanck.
Lyallii, Harv. Port Phillip Heads.
filipendula, Harv. Port Fairy.

Dasya, Ag., Harv. Phy. Aus., Plate 174, 278, 257, 3.

D. Gunniana, Harv. Ocean Grove.
Laurenciana, Harv. Torquay.
villosa, Harv. Point Lonsdale.
macroura, Harv. Port Phillip Heads.
hapalathrix, Harv. Ocean Grove, Har. Phy. Aus., vol. ii, pl. 88.
Faradaye, Harv. Ocean Grove, H.P.A., vol. iii, pl. 173.
Haffice, Harv. Barwon Heads, H.P.A., vol. iii, pl. 143.
baccarioides, Harv. Western Port.
Tasmanica, Sond. Western Port.
Muelleri, Sond. Barwon Heads, H.P.A., vol. i, pl. 31.
wrangelioides, Harv. Torquay.
Wilsonis, J. Ag. Point Lonsdale.
tenera, Sond. Western Port.
mirocladiodes, Harv. Ocean Grove.
plumigera, J. Ag. Ocean Grove.
hormocladus, J. Ag. Cape Schanck.

D. cerameoides, J. Ag. Point Lonsdale.
urceolata, Harv. Port Fairy.
pellucida, Harv. Sorrento.
atactica, J. Ag. Port Phillip Heads.
australis, J. Ag. Port Phillip Heads.
Bolbochœte, Harv. Ocean Grove.
verticellata, Harv. Port Phillip.
lenormandiana, Ag. Mouth of Glenelg River.
dictyuroides, J. Ag. Port Phillip Heads.
hormoclados, J. Ag. Port Phillip Heads.

ZOOSPERMEÆ.

Siphonaceæ.

Caulerpa, Lamouroux. Harv. Phy. Aus., Plates 30, 107, 95, 161, 178, 172.
C. scalpelliformis, Ag. Brighton Beach, Harv. Phy. Aus., vol. i, pl. 17.
falcifolia, Harv. Western Port.
trifaria, Harv. Western Port, Harv. Phy. Aus., vol. v. pl. 261.
Harveyi, F. v. Müeller. Western Port.
Sonderi, F. v. M. Flinder's, Harv. Phy. Aus., vol. iii, pl. 167.
Abier-marina, J. Ag. Flinders.
Brownii, Endl. Sorrento.
hypnoides, R. Br. Ocean Grove, Harv. Phy. Aus., vol. ii, pl. 84.
Muelleri, Sond. Ocean Grove, Harv. P. A., vol. i, pl. 2.
sedoides, Ag. Red Bluff, Hobson's Bay, Harv. Phy. Aus., vol. ii, pl. 72.
vesculifera, Harv. Western Port.
simpliciuscula, Ag. Port Phillip Heads, Harv. Phy. Aus., vol. ii, pl. 65.
papillosa, J. Ag. Queenscliff.
cactoides, Ag. Cape Schanck, Harv. Phy. Aus., vol. i, pl. 26.
alternifolia, J. Ag. Ocean Grove.
curvifolia, J. Ag. Ocean Grove.
obscura, J. Ag. Ocean Grove.
geminata, J. Ag. Western Port.

Avrainvillea, J. Ag.
A. obscura, J. Ag. Port Phillip Heads.

Callipsygma, J. Ag.
C. Wilsonis, J. Ag. Port Phillip Heads.

Codium, Ag. Harv. Phy. Aus., plate 41.
C. mucronatum, J. Ag. Port Phillip Heads.
tomentosum J. Ag. Queenscliff.
Muelleri, Kütz. Ocean Grove.
elongatum, J. Ag. Sorrento.
spongiosum, Harv. Port Phillip Heads, Harv. Phy. Aus., vol. i, pl. 55.
Bursa, Grev. Ocean Grove.
Clypiatum, J. Ag. Ocean Grove.
galeatum, J. Ag. Port Phillip Heads.
pomoides, J. Ag. Port Phillip Heads.

Vaucheria, D.C.
V. velutina. Flinders (Brackish stream).
clavata. Flinders.

Bryopsis, Lamourx.
B. plumosa, Lamx. Flinders (mouth of stream).
clavœformis, J. Ag. Port Phillip Heads.
baculifera, J. Ag. Port Phillip Heads.
gemellipora, J. Ag. Port Phillip Heads.

Udotea, Lamourx.

U. peltata. Flinders.
infundibuliformis. Flinders.

Dasycladeæ.

Polyphysa, Lamour. Harv. Phy. Aus., plate ii.

P. peniculus, Lamour. Flinders.
cliftoni, Harv. Port Phillip, Har. Phy. Aus., vol. v, pl. 255.

Valoniaceæ.

Apjohniæ, Harv.

A. lætevirens, Harv. Western Port, Harv. Phy. Aus., vol. 1, pl. 5.

Dictyosphœria, Dec.

D. sericea, Harv. Port Phillip Heads.

Ulvaceæ.

Porphyra, Ag. Harv. Phy. Aus., vol. v, pl. 265.

P. vulgaris, Ag. Shores of Port Philiip.
laciniata, Ag. Shores of Port Phillip.

Ulva, L.

U. lætevirens, Areschoag. Port Phillip Heads.
latissima, J. Ag. Port Phillip.
rigida, Harv. Western Port.

Ulothrix.

U. zonata. Flinders.
æquatilis. Flinders.

Punctata.

P. latifolia. Flinders.

Œnteromorpha, Link.

E. bulbosa, Lu. Port Phillip Heads.
clathrata, Kütz. Port Phillip Heads.
flexuosa, Walf. Port Phillip Heads.
Hobkirkii, Harv. Port Phillip Heads.
lingulata, J. Ag. Port Phillip Heads.
opposita, J. Ag. Port Phillip Heads.
compressa, Grev. Flinders.

Bangia, Lyng.

B. pulchella, Harv. Warrnambool.

Cladophora, Kuetz. Harv. Phy. Aus., plates 78, 101.

C. Bainesii, Müel. and Harv. Port Phillip, Harv. Phy. Aus., vol. ii, pl. 112.
Feredayi, Harv. Cape Schanck, Harv. Phy. Aus., vol. i, pl. 47.
gracilis, Griff. Port Phillip Heads.
acrosiphonia, J. Ag. Port Phillip Heads.

Chœtomorpha, Kuetz.

C. Darwinii, Kuetz. Port Phillip.
œrea, Kuetz. Warrnambool.
valida, Hook. Western Port.

Ædogonium, Link.

Æ. capillare, Kuetz. Western Port.
vesicatum. Western Post.

Conferva, Tries.

C. Darwinii. Flinders.
maxima. Flinders.
arinosa, Carm. Port Phillip Heads.
valida, J. Ag. Port Phillip Heads.

No. 8.—ON THE OCCURRENCE OF EUCALYPTUS PULVERULENTA IN VICTORIA.

By A. W. Howitt.

(Read Friday, January 7, 1898.*)*

There are two passages in the systematic description of this eucalypt by the late Baron v. Mueller in the eighth decade of the "*Eucalyptographia,*" to which I desire to refer as an introduction to this paper.

First, that the *Eucalyptus pulverulenta* of Sims (1) occurs in Victoria, near Lake Omeo, near the Buchan River, between the Avon and Mitchell Rivers, and also towards Walhalla. Second, that there had not been included in the systematic definition and in the illustration of that species a eucalypt the leaves of which in aged trees become elongated lanceolar, much narrowed upwards, and even somewhat sickle-shaped, though their base remains rounded and their stalk very short. Moreover, some of the leaves become alternate or scattered.

The inference to be drawn from these statements is that not only does the typical form of the species occur in Victoria, but that both in the north-eastern district and in Gippsland there is a variety with elongated sessile opposed leaves.

For some time I have felt considerable difficulty as to the occurrence of *Eucalyptus pulverulenta* in Victoria in its typical form. In the Gippsland localities which are known to me, as at Omeo, Buchan, Providence Ponds (between the Avon and Mitchell Rivers), towards Walhalla, and elsewhere, I have seen the variety with elongated lanceolar leaves, but not the typical *Eucalyptus pulverulenta.*

I have now again carefully considered the specimens in my collection, and also some new material either collected by me or supplied lately by correspondents.

I have to thank Mr. J. G. Luehmann, Curator of the National Herbarium in Melbourne, for most kindly making available to me the specimens therein of *Eucalyptus pulverulenta* and other kindred eucalypts.

Unfortunately, those specimens which were used by Baron v. Mueller for his definition and for the illustration of species in the

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(1) "Botanical Magazine," Vol. xlvi, 1819, t. 3087.

"*Eucalyptographia*," have been mislaid during changes consequent on the decease of the Government Botanist, and cannot now be found.

The consideration of the evidence has led me to the conclusion that the typical *Eucalyptus pulverulenta* is not found in Victoria, but only the variety with opposed, elongated lanceolar leaves in the aged trees. For this I propose the name as a variety, of "lanceolata."

It seems to me preferable to give a pretty full definition of the *Eucalyptus pulverulenta*, variety *lanceolata*, than merely to enumerate the characters which differentiate it.

It occurs between the Pilot range and Beechworth (F.v.M.), near the Ovens River (C. Falk), and in the Ovens district (D. Ingle). In Gippsland I have observed it near Buchan, at Providence Ponds (between the Avon and Mitchell Rivers), near Ostler's Creek, on the Walhalla Road, between Darlimurla and Mirboo North, at Monkey Creek between Sale and Port Albert, and at Moe.

It grows as a small tree, or a tree rising to the height of 40 feet to 50 feet. The bole is usually short, and in the taller forms the limbs are not infrequently somewhat thick as compared to the trunk, and are curved, twisted, or angular. The lower branches frequently droop, especially in the taller forms.

Bark outwardly grey, within reddish brown, shortly fibrous and brittle, resembling in some degree in outward appearance the bark of *Eucalyptus macrorrhyncha*.

The inner bark has a smell which while eucalyptine has been likened by some to a terebinthine odour.

The outer bark peels from the smaller boughs, leaving them smooth and brown in colour.

Seedlings have opposed sessile leaves, which are almost circular in the lower pairs, but ovate to pointed ovate in the higher.

The leaves and, indeed, the young plants are characterised by an ashy-grey mealy bloom, with more or less of an underlying dull green tint showing through. I have observed the stem to be reddish and although warty to be smooth.

Young saplings of 4 feet or 5 feet in height have opposed sessile, rounded, cordate to ovate, and also ovate-pointed leaves.

On the upper shoots of somewhat taller saplings the leaves become broadly ovate-lanceolar, 3 to 4 in. long by half that in width. Such leaves, indeed the leaves of saplings generally, are less mealy than the young plants, excepting the new shoots, or at time of flowering, and are of a dull green, with at the same time a distinct ash-grey tinge.

The venation of the young leaves is not always distinct. The mid-rib is usually well marked, and in some localities comparatively wide at its base. The stem, leaf-stalk, mid-rib, and leaf-edge in some cases are dark red in colour.

On the leaves of strong saplings the venation is often well marked. The lateral veins diverge at angles between 40° and 50°, and are somewhat apart. The marginal vein not always distinguishable, and placed irregularly distant from the edge.

In the leading shoots of strong saplings, the leaves are lengthened so as to become lanceolar, or somewhat sickle-shaped, or falcate. On aged trees the whole of the leaves, excepting, perhaps, those on the lower drooping boughs, are usually long-lanceolar, and opposed; but in places, especially high up, show a tendency to be alternate or scattered. Almost always a shoot is terminated by a pair of opposed leaves.

In the north-eastern district the leaves appear to be thinner in texture than those of trees in Gippsland, which are sometimes thick and leathery. In such cases the venation is somewhat hidden, but dots are plentiful.

The flowers are mostly axillary, and are to be found even on saplings, not more than 5 feet in height. The peduncle is rounded, though I have occasionally observed a trace of flattening, and it is from three-eighths to one-half of an inch long. Buds are about as long as, and the lid may be one-third to one-half, of the length of the calyx-tube. Form of bud, truncate conoid; lid somewhat mammilate; filaments yellow; anthers all fertile, almost oval, opening by long parallel slits; style rather short, and scarcely dilated. The number of flowers in a head from three to six, rarely two. The trees flower in Gippsland about October, and April.

The fruits are sessile, or almost so, and vary somewhat in size and shape. Of a number which I have examined from the different places mentioned some were top-shaped, being about equal in height and in breadth at the rim; less frequently semiovate top-shaped. Rim somewhat marked, occasionally almost flat, but vertex sometimes convex, and occasionally strongly so. The valves are not large, are deltoid, exerted slightly and bent a little inwards.

In a number of fruits collected in Gippsland I found those having three, four, and five valves in the ratios of 5, 9, 1.

The timber of the Victorian variety is somewhat dark coloured, liable to be pipy and of no economic value unless for fuel in default of better.

The most westerly locality where I found this tree is Moe, in Gippsland, 80 miles from Melbourne. From Moe to Bunyip River, a distance of 32 miles, there extends the great forest of Western

Gippsland, within which there are but few spots where *Eucalyptus pulverulenta* might be able to find a habitat. But at Bunyip the country again changes to comparatively poor sandy and clayey soil flanking the mountains which end in the Dandenong Ranges. On these lands is found as part of an open forest *Eucalyptus Stuartiana*, locally known as "apple-tree," and of which Baron v. Mueller remarks that there is every reason to assume that the variety of *Eucalyptus pulverulenta* with elongated leaves is merely a state meditating a transit to *Eucalyptus pulverulenta.*

In tracing out *Eucalyptus pulverulenta* in its lanceolate variety through Gippsland I was struck by some points in which as to the foliage, this tree, as at Moe, resembled *Eucalyptus Stuartiana.* Again, in tracing out this latter from Bunyip to near Lilydale I was struck, not only by the differences which distinguish it from, but also by the many characters which it has in common with, *Eucalyptus pulverulenta* in its lanceolate variety.

The young form of *Eucalyptus pulverulenta* of Victoria nearly resembles the mature form of the New South Wales species. Baron von Mueller says that it is distinguishable from *Eucalyptus Stuartiana* only in its foliage; and to this I would add that it is only in its young state that the pulverulent character is equally apparent in the latter as in the former.

In this connection I may say that I am fully in accord with Mr. J. H. Maiden when he says, at p. 523 of the "Useful Native Plants of Australia," that it is a question whether they ought not to be united.

The sessile, comparatively short and wide leaves of the type in its mature state, the elongated, although sometimes still sessile, comparatively narrow leaves of the lanceolate variety, and the similar leaves but with attenuated base, and comparatively long petioles of *Eucalyptus Stuartiana*, indicate the direction and degree of the changes which have taken place.

The following may serve as a rough approximation of the lengthening of the leaf, and the development of a leaf stalk, commencing with the typical *Eucalyptus pulverulenta* and ending with *Eucalyptus Stuartiana.* The measurements were made in inches, disregarding small fractions, and those leaves were chosen which appeared to represent the larger size in each case of the mature foliage :—

Marulan, N.S.W.	2·	Monkey Creek, Vic.......	6·
Ovens district, Vic.	3·	Moe, Vic.	6·
Buchan ,, ...	5·	Bunyip ,, ...	7·
Darlimurla ,, ...	6·	Croydon	7·

In order to see whether any generally distinctive character might become evident by a comparison of the length and breadth of leaves and the length of the leaf-stalk, I measured a number of

leaves of mature trees of *E. pulverulenta* and *E. Stuartiana* and tabulated the results :

Name.	Locality.	Length.	Breadth.	Petiole.
		In relative proportions.		
E. pulverulenta............	Marulan, N.S.W..	1·6	1·	Sessile.
E. pulverulenta, var. lanceolata.*	Pilot Range, Vic..	3·	1·	Sessile.
Do	Ovens District, Vic.	4·	1·	
Do	Ovens River, Vic.	5·	1·	·3
Do	Buchan..............	6·	1·	Sessile.
Do	Darlimurla, Vic....	11·	1·	·3
Do	Monkey Crk., Vic.	{ 6· 7·	1· 1·	·8 ·4
Do	Moe, Vic............	6·	1·	Sessile.
E. Stuartiana	Bunyip...............	9·	1·	·5
Do	Black Flat, Vic....	8·	1·	·5
Do	Burwood	10·	1·	·6
Do	Croydon	6·	1·	·8 ·6

* Labelled by F.v.M. as *E. cinerea.*

Properly these data ought to have been extended to include a greater number of measurements. But even as they are, they suggest a gradual divergence from the New South Wales type in coming south-westward from the habitat of *Eucalyptus pulverulenta.* So far the discussion of *Eucalyptus pulverulenta* negatives the belief that the New South Wales type has so far been found in Victoria. Instead there is found a marked variety having a young form similar to the type of the species, and an adult form with opposed lanceolate leaves. Properly speaking, there are in Victoria two varieties each of which is marked by the abovementioned characters.

But in one variety, namely, " lanceolata," the leaf-stalk is sometimes short or absent, and the base of the leaf more or less rounded.

In the other variety, namely, *Eucalyptus Stuartiana,* the petiole is comparatively long, and the base of the leaf is much attenuated.

The ash-coloured or white mealiness of the leaves, stem, and buds is not so apparent in some localities in Gippsland as in trees near Beechworth. It is absent, or only seen exceptionally, in *E. Stuartiana* in a mature state. But in the young forms of both it is perhaps as well exemplified as in the type of the species

A third but more distant variety is the eucalypt, to which the aborigines of Gippsland apply the name of " But But," and which Baron v. Mueller has included with *E. Stuartiana.*

In its young form it resembles *Eucalyptus pulverulenta*, but both the young and old trees have constant and definite characters, which in my opinion must separate it from *Eucalyptus Stuartiana.*

The discussion of this question and of the proper position of "But But" must remain to a future occasion. All that I desire now to point out is that by its floral characters and by its young form it is one of the group which gathers round about *Eucalyptus pulverulenta.*

The opposition of the leaves of aged trees, which is one of the distinguishing characters of this group, is well marked in one of the forms of *Eucalyptus viminalis*, which occurs from Cape Schanck to Whittlesea, beyond Melbourne, and it may have a wider range.

Not only are its lanceolar or falcate leaves habitually opposed, but locally, as at Glen Iris, I have observed the foliage as a whole to have a well-marked dull ashy tint.

I am led, therefore, to the conclusion that the term *Eucalyptus pulverulenta* in its wide sense includes several eucalypts which as varieties are near to or depart from the original type, which may be now perhaps best seen in the young state of *Eucalyptus pulverulenta* of New South Wales.

If this conclusion can be maintained, then the transition which Baron v. Mueller postulates as that of *Eucalyptus pulverulenta* to *Eucalyptus Stuartiana* might rather be considered as of all the existing members of this group from some Eucalyptus represented by the young form of each, but of which the older type is now extinct.

REFERENCES TO THE PLATES.

Illustrations of *Eucalyptus pulverulenta*, variety *lanceolata.*

PLATE XXVI.—Part of spray of sapling from Buchan.

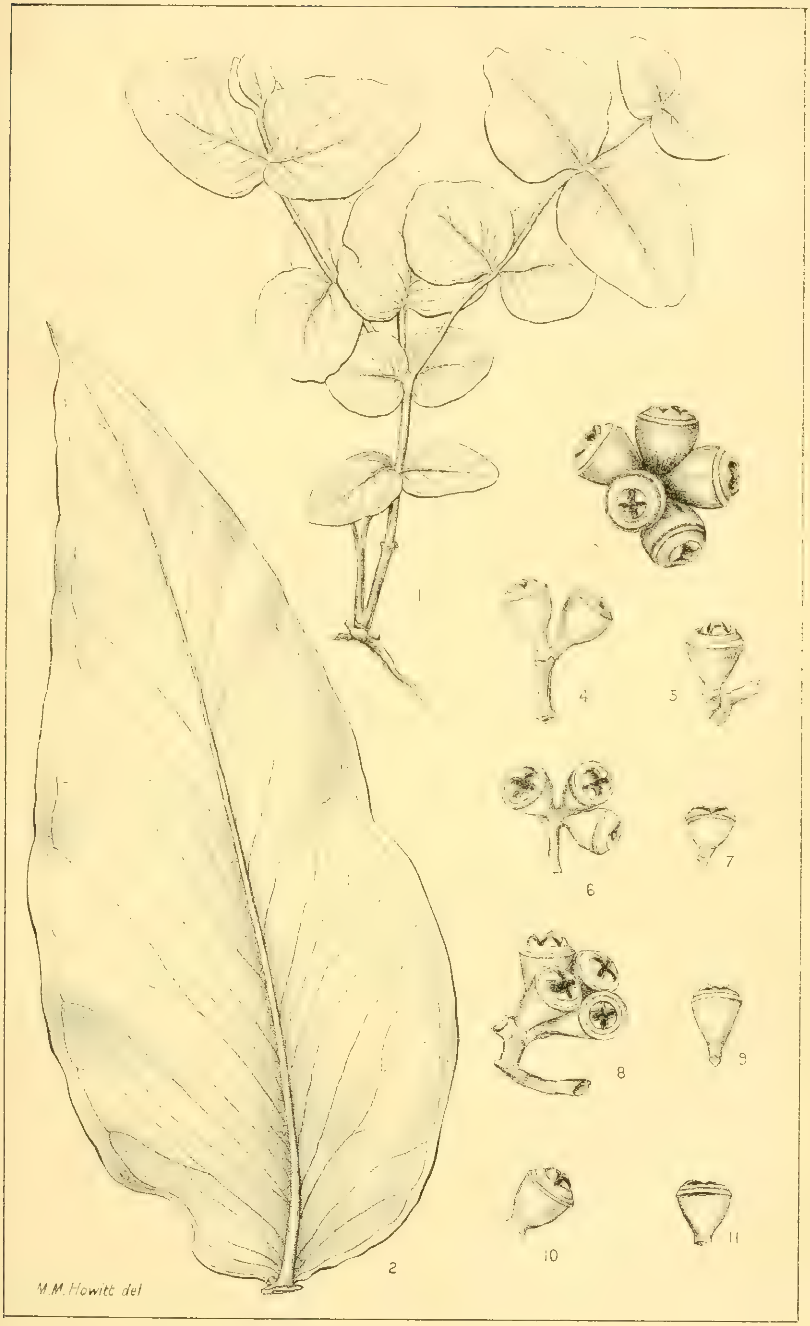
PLATE XXVII.—1. Seedling from Moe.
2. Leaf of sapling, low down, from Buchan.
3. 4. 5. Fruit from Moe.
6. 7. Fruit from Monkey Creek.
8. 9. Fruit from Woolgulmerang.
10. 11. Fruit from Buchan.

PLATE XXVIII.—1. Sucker from stump, Darlimurla.
2. Leaf of aged tree, Darlimurla.

PLATE XXIX.—Spray of leaves of aged tree from Buchan.

Eucalyptus pulverulenta.

By A. W. HOWITT, F.G.S.



Eucalyptus pulverulenta.

By A. W. HOWITT, F.G.S.

Eucalyptus pulverulenta.

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Eucalyptus pulverulenta.

By A. W. HOWITT, F.G.S.

No. 9.—A SHORT DICHOTOMOUS KEY TO THE HITHERTO KNOWN SPECIES OF EUCALYPTUS.

By J. G. LUEHMANN, F.L.S. (Curator, National Herbarium, Melbourne.)

(*Read Tuesday, January* 11, 1898.)

THE scheme herewith laid before the members of the Association, to classify the species of the genus Eucalyptus according to the fruits, is not, I may state at the outset, meant to supersede the excellent anther-system introduced by Bentham ; the latter being in my opinion the most reliable which, with our present knowledge, can be devised. Frequently, however, when specimens are gathered, expanded flowers, or even well-advanced buds, are not available, while nearly every adult tree bears fruits as well as young flower-buds, and in most cases, though not in all, the species can by their aid and that of the leaves be determined with tolerable accuracy. The present arrangement should, therefore, be looked upon as devised to act as an auxiliary guide only, without any full descriptions, and is for this reason submitted in the form of a key. The primary character chosen is that of the fruit-valves, whether quite enclosed or whether the points protrude beyond the rim, or whether the top of the fruit is convex with every part raised above the rim ; secondarily, the shape and size of the fruit are taken into consideration. De Candolle's classification, based on the shape of the operculum, is relied upon for further sectional divisions. While the majority of the species are without difficulty assigned to their respective divisions, there are others which form a transit and, in these cases doubts will arise, especially when we consider their remarkable variability. Even with complete material I have sometimes found it difficult to fix the limits of a species, although I devoted a great deal of time to the study to the genus while assisting the late Baron von Mueller in the elaboration of his Eucalyptographia, for which I worked up the very extensive material that had accumulated since the publication of the third volume of the Flora Australiensis. This mutability of form is well illustrated by the fact that a dozen kinds, raised from Australian seeds, have been described as new species in Europe and America by botanists of repute, although it seems improbable that they would receive seeds of a single species that had not already come under Baron von Mueller's notice. While

sometimes even a minor character appears to be constant, and affords a pretty sure clue to the identification of a species, in other cases characters that in most plants would be considered of the greatest importance will be found unreliable in Eucalypts. Thus it is also with the bark, which, though generally such a good guide, varies in some instances to a remarkable degree. This is well exemplified by Eucalyptus viminalis; this tree, which grows around the Melbourne herbarium building, shows here, in its sapling state, a smooth, whitish bark, until it attains a diameter of from 4 to 6 inches, then gradually the outer layers remain attached, at first near the base only, becoming rough and brown; as the plant gets older, these layers creep higher and higher up the stem, until, in aged trees, the whole of the trunk and also the larger branches are covered with a thick, rugged, dark brown bark. Within 10 miles inland from Melbourne, already the tree changes its character in this respect, inasmuch as only the lower part of the stem is covered with this rugged bark, while another 10 miles further towards the ranges, this species presents a smooth, white trunk, except, perhaps, just near the ground. Although the floral characters remain the same, yet, any one seeing only the two extreme forms would certainly consider them two distinct species. Euc. leucoxylon shows similar anomalies. As another instance of the difficulty of arriving at a correct limitation of the species of Eucalyptus, I may mention the fact that Bentham wrote that after he had finished his description of all the species of this genus for the Flora Australiensis, he considered it necessary to re examine the whole of the collections, a thing which, for want of time, he did not do with any other group of plants. There is one feature which will, probably, throw more light upon the limits of species as well as their affinities, with which we are not yet sufficiently acquainted; this is the character of the seedlings. I venture to express a hope that in the near future one of our botanic gardens will undertake the investigation of this subject, which requires not only great knowledge and care, but also certain means that are only at the command of few people.

In submitting this contribution to Australian botany, I trust that with all its shortcomings it will prove of some service in identifying the species of our most important genus of timber trees.

No.		No.
	Calyx four-toothed	1
	Calyx truncate	2

(No. 5, *E. tetraptera* shows an approach to a four-toothed calyx.)

1. Fruit fully $\frac{1}{2}$ inch long, *E. tetrodonta*.
   Fruit under $\frac{1}{2}$ inch long, *E. odontocarpa*.

   (Probably a variety of the above.)

No. — No.

2. Stamens united in four bundles 3

(This character is generally also discernible in the fruit by four depressions where the stamens had been inserted.)

Stamens free and inserted all around the inside of the calyx 5

3. Fruit more than 1 inch in diameter, convex above the rim of the calyx, *E. erythrocorys.*

Fruit less than 1 inch in diameter, the valves enclosed 4

4. Leaves mostly opposite, ovate-lanceolate, mealy-white, *E. tetragona.*

Leaves scattered, lanceolate-falcate, dull green, *E. eudesmioides.*

5. Fruit quadrangular, about $1\frac{1}{2}$ inches long, reddish, *E. tetraptera.*

Fruit terete or irregularly angular 6

6. Fruit-valves quite enclosed in the capsule 7

Fruit-valves either quite exserted or the points reaching the level of the rim 64

7. Flowers mostly paniculated 8

Flowers in simple umbels 35

(Occasionally the inflorescence will appear paniculated in this section through the falling off of the leaves.)

8. Leaves mostly opposite... 9

Leaves scattered 13

9. Leaves connate 10

Leaves not connate 11

10. Leaves about 6 inches long, 3 inches broad, *E. perfoliata* (allied to No. 31, *E. corymbosa*).

Leaves not exceeding 2 inches in length, *E gamophylla.*

11 Leaves mostly ovate, not exceeding 2 inches in length 12

Leaves lanceolate, at least 3 inches long 13

12. Calyx bristly, *E. setosa.*

Calyx glabrous, *E. aspera.*

13. Fruit $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter, *E. ferruginea.*

Fruit not exceeding $\frac{1}{3}$ inch in diameter, *E. clavigera.*

(*E. grandifolia* and *E. Papuana* are varieties of this.)

14. Leaves mostly peltate, *E. peltata.*

Leaves attached to the stalks at the base 15

15. Leaves of equal colour on both sides 16

(See also Nos. 31 and 34.)

Leaves paler beneath than above 24

16. Fruit at least $\frac{1}{3}$ inch in diameter, more or less urceolate 17

Fruit rarely exceeding $\frac{1}{4}$ inch 19

No.		No.
17.	Flowers and fruits sessile, *E. eximia.*	
	Flowers and fruits pedicellate	18
18.	Leaves lanceolate, operculum double, *E. maculata* (this includes as varieties *E. citriodora* and *E. melissiodora*).	
	Leaves ovate, operculum single, *E. latifolia.*	
19.	Leaves from orbicular to ovate, *E. polyanthema.* (*E. populifolia*, which sometimes has the valves barely exserted, is readily distinguished by the dark, shining leaves, those of *E. polyanthema* being quite dull and greyish-green.)	
	Leaves from lanceolate-falcate to ovate-lanceolate ...	20
20.	Operculum conical, *E. hemiphloia.* (This includes *E. albens* as a mealy-white variety, and probably, also, *E. Bowmani*, described from insufficient material.)	
	Operculum hemispherical, rarely shortly conical ...	21
21.	Leaves ovate-lanceolate...	22
	Leaves lanceolate	23
22.	Fruit truncate-ovate, about 2 lines long, *E. Behriana.*	
	Fruit urceolate, 1 line long, *E. brachyandra.*	
23.	Leaf-veins very oblique, not numerous, anastomosing, *E. largiflorens* (= *E. bicolor*, Cunn.).	
	Leaf-veins very diverging, numerous, hardly anastomosing, *E. tesselaris.*	
24.	Fruit with eight prominent longitudinal ridges, over 1 inch long, *E. ptychocarpa.*	
	Fruit without prominent ridges	25
25.	Branchlets with ferrugineous hairs, *E. Torelliana.*	
	Branchlets glabrous	26
26.	Fruit urceolate	27
	Fruit ovate or globose-truncate	33
27.	Fruit not exceeding 4 lines in length, *E. trachyphloia.*	
	Fruit over ½ inch long	28
28.	Operculum broader than the calyx, *E. Watsoniana.*	
	Operculum not broader than the calyx	29
29.	Fruit under 1 inch in diameter	30
	Fruit exceeding 1 inch in diameter	32
30.	Peduncles stout, pedicels none, *E. Abergiana.*	
	Peduncles slender, flowers pedicellate...	31
31.	Leaves lanceolate, *E. corymbosa.* (Including as varieties E. terminalis, E. dichromophloia, and E. pyrophora, as I find it impossible to draw a clear line of demarcation; the specimens from the dry interior and from the north-west have the leaves frequently of equal colour on both sides, and the fruits are occasionally rather ovate-truncate than urceolate.)	
	Leaves very large, ovate, *E. Foelscheana.*	

No. | No.

32. Flowers white, rarely pink; seeds very large, black, not winged, *E. calophylla.*
   Flowers red; seeds brown, winged, *E. ficifolia.*

33. Fruit truncate globular, sessile, *E. Howittiana.*
   Fruit truncate-ovate, pedicellate 34

34. Operculum depressed-hemispherical, *E. Cloeziana.*
   Operculum more or less conical, *E. paniculata.*

   (The variety fasciculosa from the dry north-west of Victoria differs in having the leaves of equal colour on both sides and the bark of the trunk smooth.)

35. Fruit two-celled, *E. phoenicea.*
   Fruit with three or more cells... 36

36. Fruit nearly 2 inches long, *E. miniata.*
   Fruit not exceeding 1 inch 37

37. Operculum projecting beyond the rim of the calyx ... 38
   Operculum not broader than the calyx 39

38. Leaves somewhat paler beneath, *E. corynocalyx.*
   Leaves of equal colour on both sides, *E. urnigera.*

39. Leaves opposite... 40
   Leaves scattered 41

40. Leaves orbicular, *E. Kruseana.*
   Leaves lanceolate, *E. doratoxylon.*

41. Leaves with several longitudinal veins almost parallel with the midrib 42
   Leaves with the veins all more or less diverging from the midrib 43

42. Operculum conical, leaves rather small, *E. stellulata.*
   Operculum hemispherical, leaves large, *E. coriacea* (= E. pauciflora).

43. Leaves much paler beneath, *E. diversicolor.*

   (Occasionally cultivated under the name of E. colossea. E. marginata has the valves sometimes enclosed, and is then distinguished from E. diversicolor by the conical operculum.)

   Leaves of equal colour on both sides or nearly so ... 44

44. Pedicels elongated 45
   Pedicels short or none 47

45. Operculum hemispherical, *E. sepulcralis.*
   Operculum conical 46

46. Leaf-veins very spreading, *E. longifolia.*
   Leaf-veins very oblique *E. leucoxylon.*

47. Fertile seeds membranously winged, *E. Todtiana.*
   Fertile seeds not winged 48

No.		No.
48.	Fruit much contracted at the orifice, nearly globular	49
	Fruits but slightly or not at all contracted	50
49.	Fruits nearly 1 inch in diameter, *E. buprestium.*	
	Fruits about $\frac{1}{4}$ inch in diameter, *E. piperita.*	
	(Some specimens from near Port Jackson have almost urceolate fruits, but seem gradually to pass into the other form.)	
50.	Fruits nearly 1 inch in diameter, *E. Planchoniana.*	
	Fruits rarely exceeding $\frac{1}{2}$ inch...	51
51.	Peduncles mostly recurved	52
	Peduncles erect...	53
52.	Operculum conical, *E. decurva.*	
	Operculum hemispherical, *E. Cooperiana.*	
53.	Base of the calyx as well as of the operculum abruptly dilated into a furrowed ring, *E. torquata.*	
	Base of calyx and operculum without these dilatations	54
54.	Peduncles short and thick, usually much flattened, *E. incrassata.*	
	(An extremely variable species; E. dumosa seems to pass into it by almost imperceptible degrees, although it can generally be distinguished by smaller flowers and fruits and less flattened peduncles. E. grossa, which is the same as E. pachypoda, appears to be also a variety with blunt, but rather long, operculum. See also No. 108, E. gonianthe.)	
	Peduncles nearly terete, mostly slender	55
55.	Calyx angular	56
	Calyx terete	57
56.	Fruit about $\frac{1}{4}$ inch long, *E. gracilis.*	
	Fruit about $\frac{1}{2}$ inch long, *E. ochrophloia.*	
	(Perhaps a variety of the above).	
57.	Calyx and operculum granular—rough	58
	Calyx and operculum smooth	60
58.	Large tree, with fibrous bark; leaves mostly very inequilateral, *E. obliqua.*	
	(Sometimes cultivated under the name of E. fissilis.)	
	Shrubs or small trees with smooth bark	59
59.	Leaves rather small, nearly straight, *E. stricta.*	
	(This is the typical E. stricta of Sieber, well described in Mueller's Eucalyptographia, with reniform anthers. Bentham, in Flora Austr. III, 217, apparently had a mixture of two species before him, describing the fruit of E. stricta, but the anthers of another species.	

No. No.

Leaves large, falcate; umbels generally enclosed in large bracts while in bud, *E. virgata.*

(Although I believe that Baron von Mueller was correct in including this also as a variety in E. stricta, yet I have kept it distinct as the appearance of the extreme forms is so very different. Both seem confined to the south-eastern parts of New South Wales. Bentham had also in this case a mixture before him, viz., a few specimens of the genuine E. virgata, but mostly those of a large tree allied to E. haemastoma, afterwards described by F. v. Mueller as E. Sieberiana. E. obtusiflora seems to have been described by De Candolle from imperfect material; an original leaf and a sketch of the specimen point, perhaps, to E. haemastoma, but a second leaf is quite different. The name had better be discarded.)

60. Leaves nearly straight, very shining, *E. fœcunda.*

(Includes E. loxophleba as a variety.)

Leaves falcate, inequilateral, dull green or hardly shining 61

61. Fruits about $\frac{1}{2}$ inch in diameter, *E. patens.*
Fruits not exceeding $\frac{1}{3}$ inch 62

62. Fruit generally 5 or 6 celled, *E. Bosistoana.*
Fruit mostly 4-celled 63

63. Fruit truncate-ovate, *E. odorata.*
Fruit truncate-globular, *E. melliodora.*

(When in flower E. melliodora is readily distinguished by the outer stamens being sterile. In Mueller's Eucalyptographia the anthers are not correctly drawn; they open by terminal pores.)

64. Flowers generally paniculated... 65
Flowers mostly in simple umbels 74

65. Leaves distinctly paler beneath, *E. Raveretiana.*
Leaves of equal colour on both sides 66

66. Leaves opposite... 67
Leaves scattered 68

67. Fruit truncate-ovate, about 4 lines long (a box-tree) *E. pruinosa.*
Fruit truncate-globular, 2 or 3 lines long (an ironbark tree), *E. melanophloia.*

68. Leaves ovate, or orbicular 69
Leaves lanceolate 70

69. Calyx about 3 lines in diameter, *E. oligantha.*
Calyx under 2 lines in diameter, *E. populifolia.*

70. Operculum about 3 lines long, *E. siderophloia.*
Operculum not exceeding 2 lines 71

No.		No
71.	Fruit-valves much exserted, *E. microtheca.*	
	(As pointed out already by Baron von Mueller, in his Eucalyptographia, Turczaninow's *E. brachypoda*, to which Mr. Bentham referred this, must be some other species, probably an aberrant form of a known plant.)	
	Fruit-valves level with, or hardly projecting beyond the rim	72
72.	Fruit 3 to 4 lines in diameter, *E. drepanophylla.*	
	(Includes as a variety *E. leptophleba.*)	
	Fruit not exceeding 2 lines	73
73.	Leaves linear-lanceolate, *E. crebra.*	
	Leaves ovate-lanceolate, lemon-scented, *E. Staigeriana*	
74.	Fruits 2 inches in diameter	75
	Fruits not exceeding 1 inch	76
75.	Leaves opposite, *E. macrocarpa.*	
	Leaves scattered, *E. pyriformis.*	
76.	Leaves paler beneath	77
	Leaves of equal colour on both sides	86
77.	Operculum broader than the calyx, *E. robusta.*	
	Operculum not exceeding the calyx	78
78.	Calyx angular, *E. botryoides.*	
	Calyx terete	79
79.	Fruit $\frac{1}{2}$ inch or more in diameter	80
	Fruit under $\frac{1}{2}$ inch in diameter	81
80.	Fruit-valves very short, hardly exserted, *E. marginata.*	
	Fruit-valves long, much exserted, *E. pellita.*	
	(Perhaps a variety of *E. resinifera.*)	
81.	Operculum longer than the calyx tube, *E. resinifera*	
	Operculum shorter than the calyx tube	82
82.	Leaves much paler beneath, the lateral veins numerous and very spreading	83
	Leaves slightly paler beneath, the lateral veins not very close and moderately spreading	84
83.	Pedicels very short, or none, *E. saligna.*	
	Pedicels elongated, *E. microcorys.*	
84.	Fruit broadest at the orifice; fertile seeds much larger than the sterile ones	84A
	Fruit contracted at the orifice; fertile seeds not much larger than the sterile ones...	85
84A.	Operculum hemispherical; fruits small, *E. propinqua.*	
	Operculum bluntly conical, *E. punctata.*	

No.		No.
85.	Fruit about four lines in diameter, rim thick, *E. pilularis.*	
	Fruit not exceeding three lines, rim thin, *E. acmenoides* (= *E. triantha* in Mueller's Census).	
86.	Leaves mostly opposite. (See also No. 138, *E. dealbata.*)	87
	Leaves scattered	91
87.	Fruit about 1 inch in diameter, top-shaped, *E. Preissiana.*	
	Fruit rarely exceeding ½ inch, truncate-ovate ...	88
88.	Leaves connate, *E. Perriniana.*	
	Leaves not connate (except sometimes in *E. Risdoni*)	89
89.	Leaves with crenulated margin, *E. cordata.*	
	Leaves with entire margin	90
90.	Leaves obtuse, ovate or almost orbicular, *E. pulverulenta.* (This includes *E. cinerea* as a variety.)	
	Leaves acute, ovate, *E. Risdoni.* (Sometimes the leaves are connate, while in age they occasionally become alternate, and assume a lanceolate form, verging towards *E. amygdalina,* with which the plant was combined by F. v. Mueller as a variety.)	
91.	Flowers and fruits on long, slender pedicels, fruits rather large	92
	Flowers and fruits on short pedicels or sessile (except sometimes *E. Maideni*)	93
92.	Fruit top-shaped, filaments red, *E. erythronema* (= *E. conoidea*).	
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94.	Calyx and operculum warty	95
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95.	Leaves lanceolate, *E. globulus.*	
	Leaves ovate, *E. alpina.*	
96.	Leaves not over 1 inch long, *E. vernicosa.*	
	Leaves much exceeding 1 inch	97
97.	Stamens straight in the bud. (See also No. 140, *E. tereticornis*)	98
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98.	Fruits of the umbel connate into one mass, *E. Lehmanni* (included in *E. cornuta* by F. v. Mueller).	
	Fruits free	99
99.	Fruit-valves ending in long, fine points, *E. cornuta.* (including as a variety *E. annulata.*)	
	Fruit-valves short	100

No.		No.
100.	Leaves lanceolate, *E. occidentalis*.	
	(including *E. macrandra* and *E. spathulata* as varieties.)	
	Leaves ovate, *E. platypus*.	
	(Baron von Mueller adopted in his Eucalyptographia Turczaninow's name of *E. obcordata*, which appellation seems to me quite misleading and has no claim to priority.)	
101.	Fruit from ½ to 1 inch in diameter	102
	Fruit mostly under ½ inch	105
102.	Top of fruit nearly flat	103
	Top of fruit convex	104
103.	Leaves shining, *E. megacarpa*.	
	Leaves dull, very coriaceous, *E. cosmophylla*.	
104.	Calyx terete, *E. Oldfieldi*.	
	(*E. Drummondi* seems a variety of this, being smaller in all its parts.)	
	Calyx angular, *E. pachyphylla*.	
105.	Leaves ovate, but acute, rarely ovate-lanceolate, *E. alba*.	
	(*E. platyphylla* I cannot distinguish from this, even as a variety.)	
	Leaves lanceolate, rarely linear	106
106.	Calyx and operculum strongly ribbed	107
	Calyx and operculum not ribbed	109
107.	Operculum quite hemispherical, *E. corrugata*.	
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108.	Operculum obtuse, *E. goniantha*.	
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109.	Calyx angular, pedicels flattened, *E. goniocalyx*.	
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110.	Fruit-valves ending in fine points	111
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111.	Capsule raised above the rim...	112
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No. | | No.

117. Pedicels very slender, at least three times as long as the calyx, *E. leptopoda*.
Pedicels short 118

118. Operculum conical or acuminate, longer than the calyx 119
Operculum hemispherical, mostly blunt, usually shorter than the calyx 120

119. Flowers shortly pedicellate, *E. redunca*.
Flowers sessile, *E. concolor*.

120. Leaf-veins fine, numerous, very divergent 121
Leaf-veins not numerous, very oblique 122

121. Stamens of expanded flowers, straight, *E. cneorifolia*.
Stamens of expanded flowers bent inwards about the middle, *E. uncinata*.
(*E. micranthera* is a variety of this.)

122. Peduncles conspicuously flattened near the top, *E. salubris*.
Peduncles nearly or quite terete 123

123. Leaves under 3 inches long 124
Leaves mostly over 3 inches long 125

124. Fruit almost flat on top, *E. coccifera*.
Capsule somewhat sunk below the narrow rim, *E. Gunnii* (typical.)

125. Fruit topshaped, leaves somewhat undulate, *E. Gunnii*, var.
(I doubt whether Baron Von Mueller was correct in including this tree in *E. Gunnii* as a variety in his Eucalyptographia, where the main figure represents it. Bentham's description of *E. Stuartiana* refers partly to this. Perhaps it will be necessary to distinguish it as a separate species, and the name of *E. undulata* would not be inappropriate.)
Fruit ovate or globose, truncate 126

126. Rim of fruit narrow, the valves inserted somewhat below it 127
Rim of fruit rather broad and flat 128

127. Flowers generally 3 in an umbel, *E. Bauerleni*.
(The real affinity is with *E. viminalis*.)
Flowers more than 3 in an umbel, *E. eugenioides*.
(The real affinity is with *E. piperita*.)

128. Leaves very pale, bark of stem hard and rugged, *E. Sieberiana*.
Leaves green, bark of stem smooth or fibrous ... 129

129. Fruit ovate-truncate, top of fruit reddish, *E. haemastoma*.
Fruite globose, truncate or shortly ovate 130

130. Leaves rather small, their oildots large and not very numerous; stem-bark fibrous, *E. amygdalina*.
(*E. dives* is an aberrant form of this. There is a variety in Tasmania with linear leaves.)

No. | No.

Leaves large, their oildots very fine and numerous; stem-bark fibrous only near the base, *E. regnans.*

(Probably correctly included in *E. amygdalina* as a variety by Bentham and Mueller.)

131. Leaves small, thick, hardly inequilateral, *E. santalifolia.*

(Includes E. pachyloma).

Leaves mostly large, inequilateral 132

132. Stems of young plants and offshoots quite quadrangular, with opposite ovate bluish-white leaves, *E. Maideni.*

(I find the above the most striking character in this remarkable species. The typical specimens have rather numerous flowers in an umbel, clavate and smooth in bud, with hemispherical but pointed operculum, and a rather long flattened peduncle. But there are forms, especially specimens collected in Gippsland by Mr. A. W. Howitt, that show an unmistakable approach to E. globulus, which in its ordinary form has such a different appearance. In other respects there is an evident affinity with E. goniocalyx. All three species have in their young state quadrangular stems and bluish leaves; the adult leaves are also somewhat similar in shape and texture. In my opinion, there are weighty reasons against the assumption that we have here a case of hybridisation, but must rather ascribe it to evolution.)

Stems of young plants nearly terete... 133

133. Veins of leaves very oblique 134

Veins of leaves very diverging 136

134. Flowers and fruits sessile, *E. capitellata.*

Flowers and fruits on short pedicels 135

135. Operculum conical, *E. macrorhyncha.*

Operculum hemispherical, *E. Muelleri.*

136. Flowers mostly three in an umbel, *E. viminalis.*

Flowers more than three in an umbel 137

137. Operculum nearly hemispherical or shortly and bluntly conical 138

Operculum conical or acuminate 139

138. Leaves green, alternate, *E. Stuartiana.*

(Distinguished from E. viminalis when the latter has more than three flowers in an umbel by the fibrous bark and roundish seedling leaves, E. viminalis having either a smooth or a rugged but never fibrous bark and lanceolate seedling leaves.)

Leaves ashy-grey, sometimes opposite, *E. dealbata.*

139. Operculum mostly ending in a beak, *E. rostrata.*

(Some varieties have a blunt operculum and form a connecting link between this and E. tereticornis. E. exserta is a variety.)

Operculum conical, not beaked 140

No. No.

140. Bark smooth ; fruit almost globose through the broad ascending rim, *E. tereticornis.*
Bark rough ; rim of fruit only slightly ascending, *E. rudis.*

E. orbifolia and *E. patellaris*, enumerated in the "*Flora Australiensis*," I have omitted, as they have in my opinion been described from too imperfect material to make their recognition at all certain ; also *E. Lansdowniana*, F. v. Mueller and J. E. Brown, as I have neither a specimen nor the description, and as Professor Tate, who has seen the plant, informs me that he does not consider it a tenable species. Nor could I take cognisance of supposed new species described in recent years from cultivated plants in Europe and America, as it seems inconceivable that seeds of a number of new species should have been sent away while the trees remained unknown to Australian botanists.

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No. 10.—SOME EUCALYPTS OF THE NEW ENGLAND TABLE-LAND.

By J. H. Maiden, Government Botanist, and Director of the Botanic Gardens, Sydney.

(*Read Friday, January* 7, 1898.)

In the month of November, 1897, I set out to botanically explore Mount Seaview, in the Upper Hastings district, a mountain in regard to the height of which erroneous ideas were held until only a few years ago. Perhaps the most important mistake is that in Banks's school map of New South Wales, in which the height is given at 6,000 feet. I propose to give notes on the topography of the country traversed in the *Agricultural Gazette* of New South Wales, and it will, therefore, be sufficient for me to explain that I approached the Seaview Range from Port Macquarie, travelling along the Port Macquarie-Walcha Road. The range is a few miles off the main road, northwards from the place of ascent of the New England Range to the table-land. While I made some botanical observations of interest on Mount Seaview, I consider them, on the whole, of inferior interest to those on the Eucalypts examined on the table-land *en route* to Walcha, and hence follow some notes on the species of this genus noted *en route* from the Myrtle Scrub (the edge of the table-land, and 5 miles from the boundary of counties of Hawes and Vernon), *via* Yarrowitch, Tia, and on to Walcha.

My most interesting discoveries are the find of *E. regnans*, F.v.M., and *E. obliqua*, L'Herit., near the eastern edge of the New England table land. Both are more specially Tasmanian and Victorian species; and while both have been recorded from southern New South Wales, the finding of them, both in abundance (the latter forming an extensive forest), in northern New South Wales, is important. An excellent series of specimens from some interesting trees belonging to what may be called the *Stuartiana* group is worthy of further investigation; and bearing in mind the finding of the two species above referred to, these specimens will be carefully compared with Tasmanian and Victorian forms.

The species observed on the table-land are arranged in the order followed in Mueller's Census.

I have a few notes on the Eucalypts found on the Seaview Range. These I propose to bring, with notes on other plants, before the Linnean Society of New South Wales later in the year.

In the article in the *Agricultural Gazette* already alluded to, I propose to enter into some detail (perhaps in diary fashion) in regard to the sequence of the Eucalypts in the country travelled over. Such information would unduly expand the present paper, though I hope it will be found interesting to readers of the *Gazette.*

It only remains for me to say that my observations and collections were made during a journey from Port Macquarie to Walcha *one way*, travelling in a buggy or on horseback 30 miles a day on the average. This will explain why many of my observations lack completeness, and why I have indicated subjects for investigation by those who come after me.

E. stellulata, Sieb.—This species is more or less plentiful all over the table-land. There are copses or thickets of it at Yarrowitch, also umbrageous small trees. At Tia and elsewhere the trunks are 2 to 3 feet in diameter. The sucker-foliage alone seemed to require special note. Mr. Deane and the author have dealt with the species as it occurs in this Colony.* The sucker leaves present a variety of shapes and sizes. In their early stages they are more or less stem-clasping and orbicular. Others are nearly reniform, while some might be described as almost bilobed, or with the outline more or less emarginate. Very many are about as broad as long, and scarcely acuminate, and from these shapes the gradation into the normal shape of the mature leaf is very gradual. Measurements give us up to $2\frac{1}{2}$ x $2\frac{1}{2}$ inches, and even a little more.

E. coriacea, A. Cunn. (Syn. *E. pauciflora*, Sieb).—This is also a species which is very widely diffused. It and the preceding species usually occur together, being more inseparable than any other two species of the genus I know. Near Yarrowitch I noticed the leaves of some seedlings which were 2 or 3 feet high. The foliage was very coarse, being both large and thick. Following are actual measurements of individual leaves :—$7\frac{1}{2}$ x $3\frac{1}{2}$ inches, $8\frac{1}{2}$ x $3\frac{1}{4}$ inches, $6\frac{1}{4}$ by $3\frac{1}{2}$ inches. Large leaves such as these were not scarce. They are a little oblique, acuminate, nearly ovate, occasionally nearly circular, and thence pass through all gradations up to ovate lanceolate. In New England apparently not known as white or cabbage gum, but white ash, in contradistinction to *E. stellulata* (black ash).

* Proc. Linn. Soc. N.S.W. [2] x. 596.

E. regnans, F.v.M.—Found near Yarrowitch. Not previously recorded further north than the ranges near the Victorian border, not many miles in New South Wales. My specimens absolutely match some from the Dandenong Ranges, Victoria. The bark is of that character well known as "Peppermint," but thicker than usual; it is almost a stringbark with ribbon branches. The tree has conoid fruits, large shiny thin leaves, bearing copious oil-dots, a character it shares with *E. amygdalina* var. *radiata*. Most of the trees I observed are small, though a few are 3 feet in diameter. Some of the umbels have a double operculum. I have for some time held the opinion, which now amounts to a positive conviction, that *E. regnans* is specifically identical with *E. amygdalina*. I am acquainted with the tree in both Victoria and New South Wales, and am familiar with *E. amygdalina* from end to end of the Colony. I think it would be best to style it *E. amygdalina* var. *regnans*.

E. amygdalina, Labill. The variety *radiata* of this species*, while not particularly abundant, attracted attention, especially between Yarrowitch and Tiara, by reason of the profusion of its flowers. Some of these trees were simply a mass of bloom. This tree is a connecting link between the type and its variety *radiata*, but I do not hesitate to classify it with the variety. The bark on the butt is more fibrous, and the foliage more dense, less drooping, and the leaves rather broader than those of *radiata* usually are. One is not surprised to see some variation in trees so far removed from the localities (which are south of Sydney) in which the var. *radiata* is most abundant. The comparative absence of watercourses in the New England localities is worthy of note in this connection. Our New England specimens have the flowers radiate and up to thirty in a head. The numerous oil-dots, a characteristic of var. *radiata* and *regnans*, are not to be mistaken. In this connection I would draw attention to the fact that specimens recently submitted to me show that there is a belt of "Peppermint" (*E. amygdalina*) starting from about 5 miles north of Tenterfield and extending out 32 miles, about 25 miles wide. It is also found south-east about 23 miles from Tenterfield on the main range and in large quantities between the main range and the Rocky River. I believe that this species has not hitherto been recorded from Queensland; the localities I have mentioned are close to the border, and search will probably soon find it in the northern Colony.

E. obliqua, L. Herit.—Three miles past Myrtle Scrub one comes across a handsome forest, in basalt country, consisting mainly of a smooth-barked eucalypt (*viminalis*) and a rough-

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* *See* Deane and Maiden, *Proc. Linn. Soc., N.S.W.* [2] x. 603.

barked one (*obliqua*). The discovery of the latter species in this part of the Colony was quite unexpected, and extends its northern range very considerably. The trees were over a hundred feet high and their trunks 3 feet and more in diameter, so that the trees are fine specimens and not the depauperate forms of mere outliers or pickets. One of my travelling companions (Mr. J. F. Campbell, L.S., of Walcha), stated that this belt of country extended for 30 miles in a general direction of north and south, roughly following the county boundary, and he believed that this species occurred over the greater portion of that county. Mr. Nivison, of Yarrowitch, states it occurs at least as far north as the Clarence River, and also in Callaghan's Swamp. Even taking the place at which I found it, reference to the previously recorded localities in New South Wales* show that it has been collected at Reidsdale in the Braidwood district, while its discovery in New England renders Mr. Rudder's alleged discovery (*loc. cit.*) of it in the Upper Williams district very probable. It would be interesting now to collect the species at points intermediate between Braidwood and New England. In the latter district it is sometimes known as messmate and bastard stringybark. At Yarrowitch it is known as white stringybark, and has been used for building purposes, *e.g.*, verandah floors; but it lacks durability in the ground. The sucker-foliage is very coarse. I have leaves 6 x 5 inches. I cannot detect any difference between my specimens and those of Mr. Deane, from Reidsdale (Braidwood).

E. eugenioides, Sieb.—This species was first observed about Yarrowitch, the fruits being small and few in the head. Thence it was not uncommon in the Tia district, where it is known as "red stringybark" (a term more generally applied to *E. capitellata*), and used for timbering the mines at Tia, and also locally for flooring boards. This species shows a double operculum.

E. capitellata was not observed on the table-land, neither was *E. macrorrhyncha*, though the latter was not rare on the Seaview Range.

E. melliodora, A. Cunn.—A rather large-fruited form, with well-defined rim. First seen on the edge of the Tia Canyon, which it skirts for many miles; it does not descend the canyon. Thereafter the tree was sparingly seen until near Walcha.

E. Stuartiana, F.v.M.—New England may be termed the *Stuartiana* country. *E. Stuartiana* I take as defined in the "*Eucalyptographia*," the description being modified from that given in the "*Flora australiensis*." I collected no less than four

* Deane and Maiden, "Observations on the Eucalypts of N.S.W.," Part 2 (*Proc. Linn. Soc., N.S.W.* [2], xii, 809).

forms between Yarrowitch and Walcha, which, at all events for the present, may be placed under *E. Stuartiana.* Variable as we know *E. Stuartiana* to be, my specimens accentuate this variability. At first I was inclined to describe at least one of the forms as new; but in any case two of them should be named as varieties. Mr. Deane and I are revising the New South Wales members of this genus, and my specimens will be dealt with in their proper place. All have fibrous bark, and are known as "Peppermint." Their timber is pinkish, with gum veins, and strongly resembles that of normal *Stuartiana.*

The four forms provisionally included under *E. Stuartiana* are as follows :—

1. A tree with box-scaly or apple-like (as we understand the term in this Colony), bark, rough, except the ultimate branchlets; suckers ovate-lanceolate, not glaucous, except the very young tips of the branchlets of the suckers. The sucker foliage reminds one a good deal of *E. viminalis;* the bark is, however, that of *Stuartiana,* and the tree (not rare, say, from 7 to 10 miles east of Walcha), is but another reminder of the intimate relationship between the two species. The fruits of this form are of the normal size. We now come to the three small fruited forms, which remind one a good deal of *E. microtheca,* but they can at once be distinguished from the latter species by the pale-coloured foliage and more spreading fruit and valves of *E. microtheca.* All are known as peppermint of one sort or another.

2.—*Broad-suckered Peppermint.*—I have two series of specimens, which, however, run into each other. Both are glaucous on the twigs, even when bearing mature foliage. The sucker foliage of both forms is very glaucous. The glaucousness also shows itself in the flush of new growth pushed out beyond the old foliage, *i.e.*, the glaucousness is not confined, as is frequently the case, to entirely new twigs or seedlings. The fruits are smaller and more pedicellate than shown in the "*Eucalyptographia*" drawing of *E. Stuartiana.* The sucker foliage is, however, similar in shape to that shown in the drawing referred to, which, however, depicts comparatively small suckers. The mature foliage is lanceolate. The dimensions of an average leaf are 4½ by ¾ inches. The sucker foliage is nearly orbicular, and 2 inches in diameter.

I first noticed this form—rather fine trees, with trunks 3 feet in diameter—between Yarrowitch and Tia. It is more or less abundant right into Walcha, where, surrounding the town, it seemed to form the bulk of the scrubby vegetation, probably because the trees have been cut down, as generally happens to them near a town. At the same time, I noticed a number of small and even medium-sized trees during a drive round Walcha.

This form is identical with specimens collected by Mr. Henry Deane at Glen Innes, and called by him "grey peppermint," and perhaps identical with "peppermint-box," collected by the same gentleman at the Bluff, near Tenterfield; early fruit only available; bark, rough and furrowed.

Mr. Augustus Hooke, of Tia Station, gave me a quantity of manna which had been collected on his station under the peppermint trees (this form now under consideration). I did not see the manna under the trees myself, but Mr. Hooke is not likely to be mistaken in regard to a tree and a product so familiar. Manna on *E. viminalis* is common enough; in fact, one form of this species is called "manna-gum" in consequence, and considering the intimate relations of *E. viminalis* and *E. Stuartiana*, which become the more pronounced the more one studies them in the field, it is not a difficult matter for me to believe that manna is also found on the latter species. I believe this is the first time manna has been recorded from *E. Stuartiana*.

3. Between Yarrowitch and Tia I got off my horse to examine what appeared to me to be an *Acacia* of the *penninervis* group. When I got close to it I found that it was the young foliage of a Eucalypt. The plant is a beautiful species in a young state, forming a dense shapely shrub, say 6 or 8 feet in diameter, and different to any other Eucalypt known to me. The young, or sucker foliage, is pale coloured, lanceolate, symmetrical, always blunt at the apex, which is sometimes rounded. The margin is crenulate, a very unusual circumstance in a Eucalypt, and the leaves are alternate, and not opposite as is the case of normal *Stuartiana*. The average size of the young leaves is $1\frac{3}{4} \times \frac{5}{8}$ in. Turning to the mature foliage, it is lanceolate, the average size of the leaves being $2\frac{3}{4} \times \frac{1}{2}$ in. The foliage is not glaucous in any part, not even the sucker foliage. The fruits are small, nearly sessile, and the valves are less exserted than in the previous form. The anthers open in parallel slits. The tree attains a size of 2 or 3 ft. in diameter. I traced it from 5 miles east of Yarrowitch to at least as far west as Tia. Mr. A. R. Crawford has sent it to me from Moona Plains, in the Walcha district. Mr. Henry Deane has collected it near Glen Innes. The range of the tree is consequently fairly considerable, and it is very desirable that we should know precisely where it occurs. Of its geographical distribution we know but little, a remark which applies to other forms of *E. Stuartiana* referred to in this paper.

4. Sixteen to seventeen miles east of Walcha I observed a drooping, singularly graceful tree, reminding one of a weeping willow. It appeared to be scarce. The height was about 50 ft., and the trunk diameter 2 ft. I have arrived at the conclusion that it forms in some respects a connecting link between Nos. 2 and 3.

Its fruits are smaller than either, reminding one of those of *E. microtheca*. The valves are well exserted. The pedicels are, on the average, as long as the fruits; the common peduncle is also much longer than that of either of the preceding forms. The adult foliage is linear-lanceolate or lanceolate, the average dimensions being, say, $5 \times \frac{3}{8}$ in. The twigs are slender; in fact the characteristic of the tree is the smallness and grace of its parts. The sucker foliage has crenulate margins like No. 3, but longer, narrower, and more pointed leaves. Some of the very young foliage is linear-lanceolate, and even linear. A good deal of the young foliage reminds one superficially of that of the Wilga (*Geijera parviflora*). The sucker foliage is alternate, not opposite like normal *Stuartiana*. This form and the preceding one undoubtedly show close affinity in their young foliage.

It will be generally agreed that these four forms are interesting, and I look forward to examination of seedlings of the series, which may perhaps throw further light upon their affinities.

E. viminalis, Labill.—In speaking of *E. obliqua*, I have alluded to the occurrence of fine trees of this species between Myrtle Scrub and Yarrowitch. The *viminalis* trees are straight, handsome-looking trees, up to 3 ft. in diameter, and as high as *obliqua*. The bark is more or less rough at the butt; above this the bark is thin, falling off in ribbons. This *obliqua-viminalis* forest is in rich basaltic soil; in poorer ground towards Walcha the *viminalis* trees are much inferior. On a ridge near Tia I observed a *viminalis* tree with larger fruits. 17 miles east of Walcha, on a flat, may be observed many trees with perfectly smooth trunks, with plum-coloured patches thereon. They have glaucous, plum-tinted, broadish (ovate-lanceolate) suckers, but are, nevertheless, undoubtedly *viminalis*. For many miles before Walcha is reached *E. viminalis* is exceedingly abundant, but most of the trees are of the usual Ribbony Gum type, with all stages of twistiness of the ribbony bark, and with much variation in the amount of rough bark at the butt.

E. tereticornis, Sm.—First seen, on the table-land, between Yarrowitch and Tia. Fine trees. On the Upper Hastings it was one of the commonest trees. It occurs sparingly on the table-land up till, say, 10 miles into Walcha.

No. 11.—A REVIEW OF THE CHARACTERS AVAILABLE FOR THE CLASSIFICATION OF THE EUCALYPTS, WITH A SYNOPSIS OF THE SPECIES ARRANGED ON A CARPOLOGICAL BASIS.

By Ralph Tate, Professor of Natural History in the University of Adelaide.

(*Read Monday, January* 10, 1898.)

Considerable thought and much patient experimental investigation have been given to devising schemes for the classification of the 150 or so species of our Eucalypts. Every possible aspect has been under consideration—the woodman's, the chemist's, the histologist's, and the systematic botantist's, and, nevertheless, no satisfactory system has been evolved. The effort to devise a scheme based on the variation of one element which shall bring together species which seem from our conception to be naturally related has failed. In this dilemma we must admit that any system, never mind its apparent artificiality, that gives better results than hitherto is the one to be adopted till a more perfect one has been elaborated. For each suggested system of classification there has been lost sight of, in my judgment, what I may call handiness of application, for many of the characters utilised involve laborious examination or are those not readily obtainable. In this connection we should have regard to the kind of material the untrained collector usually brings to us, and the conservation of which involves the least trouble to him; certainly not the bark or kino, sometimes the flowers, but more generally the leaves and fruit. By way of leading up to my proposed carpological basis of classification I will review the other characters which are available for classifactory purposes.

HABIT.

The Eucalypti comprise two habits of growth, viz., trees and shrubby trees, to which I apply the vernacular names of *Gums* and *Mallees*. I do not know if I am correct in so doing, as I have failed to find any definitions of these well-known terms.

I have constantly observed in seedlings and growths of one or two years of such gums, as *E. rostrata*, *leucoxylon*, *viminalis*, a large inflation of the base of the stem, either at the surface or just below the surface of the soil. In the species named this is eventually outgrown, but in the mallees it persists and increases in size proportionately with the development of the branches which are emitted from it—in the mallee this rudely globose bole is partially subterranean. The umbrella-like disposition of the

foliage of the taller mallees may be largely incidental to over-crowding, though it would seem to be an inherited character as it is fairly pronounced in them when they are distantly separated from one another.

TIMBER.

Two extremes in the property of timber occur, (1) the fissile or readily-splitting timber as that of *E. globulus*, *E. amygdalina*, and other so-called stringybarks; (2) the short-fibred timber as that of *E. rostrata.* Moreover, the duramen is fairly constant in colour for each species, varying from mahogany-red to yellow and white, and though the general character of the timber is invariable for each species, yet the quality of it varies according to climate and soil, so that the forester's appreciation of specific differences cannot safely be availed of for the systematic arrangement of the Eucalypts. Thus, for example, the wood of *E. rostrata* growing on river-ways is of very inferior quality as a timber, and is even rejected as firewood when other sources of supply are obtainable; but as the tree ascends the slopes of high elevations, up to about 2,000 feet in South Australia, the timber improves in quality, and at its best ranks as highly valuable.

BARK.

The differences in the nature of the outer cortical layers led Baron von Mueller (Journ. Lin. Soc., III, 1858), to arrange the species into the following groups:—

1. *Leiophloiæ*, or smooth-barked trees, as *E. rostrata*, *E. leucoxylon*, &c., and the majority of mallees.
2. *Hemiphloiæ*, or half-barked trees; bark of lower trunk persistent, of upper part and branches deciduous, as *E. hemiphloia*, *E. oleosa*.
3. *Rhytiphloiæ*, with wrinkled persistent bark, as *E. robusta*, *E. corymbosa*, *E. amygdalina*, *E. odorata.*
4. *Pachyphloiæ*, with persistent fibrous bark, as *E. gigantea*, *E. calophylla*, *E. obliqua*, and other stringy-barks.
5. *Schizophloiæ*, with persistent deeply-furrowed bark, as *E. crebra.*
6. *Lepidophloiæ*, with persistent bark on the trunk only, and forming scaly separate pieces, as *E. tessellaris.*

This cortical system has its utility; but there are several species which exhibit inconstant characters, as for example, *E. hemiphloia* in its ordinary state is typical of section 2, but in the high uplands of the Mount Torrens district of South Australia it assumes the characteristics of section 4 and is locally known as "Bastard Stringy-bark." Mr. Maiden, P.L.S., N.S.W., 4, p. 1278, 1890,

writes: "I have seen bark of *E. stellulata* (which Mueller includes in section 5), which cannot be distinguished from what are known as ironbarks."

EXUDATIONS.

Mr. J. H. Maiden, Proc. Lin. Soc., New South Wales, 1890, p. 605, as the result of extensive and repeated investigations, has shown that the *Kinos*, or astringent exudations, may be readily grouped into three sections according to their behaviour with water and with alcohol; and has proved, further, that a kino of one species invariably belongs to one group. He would employ this chemical system of grouping the Eucalypts as supplementary to, or a check upon, the anthereal (or other) system. His classification of the *Kinos* is as follows:—

(1.) The Ruby Group, which consists of ruby-coloured *Kinos*, the members of which are soluble either in cold water or in cold spirit. To this group belong *E. obliqua* and other species having kidney-shaped anthers.

(2.) The Gummy Group, whose members are soluble in cold water, but very imperfectly in spirit, owing to the gum they contain, such as *E. siderophloia* and some other ironbarks.

(3.) The Turbid Group, whose members are soluble in hot water or in hot alcohol, but the solutions become turbid on cooling; all the members of this group contain catechin, such as *E. rostrata*, *E. leucoxylon*, &c.

FOLIAGE

Don, 1832, classified the then described Eucalypts into two primary sections according to the alternate or opposite position of the leaves; but it was pointed out by Bentham, Fl. Aust., iii., p. 187, 1866, that a great majority of the species are now known to have on the young sapling, or even on adventitious barren branches of older trees, opposite leaves. The leaves of the young plants of all the species with which I am acquainted are opposite, horizontal, often sessile, bluish, and more or less oval, eventually in the great majority of species becoming alternate, lanceolate, vertical, stalked, and green. This feature has been largely illustrated by Baron von Mueller in "*Eucalyptographia*," Decade 9, and by Sir John Lubbock in his "Seedling Plants." The opposite-leaved condition would appear to be the primitive one, and in a few species, such as *E. gamophylla*, persists throughout life.

Little value can be placed on leaf-shape, as in general there is great similarity among different species, and often great diversity

in the same species; in a few species, however, the leaves of the adult plant offer very distinctive characters, such as connate in *E. gamophylla*, hispid in *E. setosa*.

Though *E. amygdalina* and *E. regnans* may be separable by leaf-shape alone, or *E. hemiphloia* and *E. Behriana* by colour, yet I think it will be conceded that such distinctions are not very reliable.

"The venation characteristic as it often is in the lanceolate leaves, the specific modifications disappear in a great measure as the leaf gets broader. In general it would appear that the horizontal leaves have the two surfaces different, and the veins very divergent or transverse, and the vertical leaves have the surfaces similar and the veins oblique."—Bentham.

Again, the leaves of some species are more distinctly or more copiously pellucid-dotted than in others; but as this feature varies with the age of the leaf it would be untrustworthy to employ it for specific distinction, except perhaps when it offers extreme contrasts.

ESSENTIAL OILS.

The drug, eucalyptus oil, is commercially obtained from the leaves, though it is also contained in the calyx. The oils from the various species of Eucalypts have the same general character, though there are most important differences between some of them, chiefly as to specific gravity and odour. In respect of the latter character *E. citriodora* and *E. globulus* offer great divergence, readily determinable by bruising the leaves: it is thus in a few species only that the odour of the foliage may be utilised for diagnostic purposes.

PETIOLE.

Messrs. McAlpine and Remfrey, "Trans. Roy. Soc. Victoria," vol. 2, 1891, have suggested the employment of the characters afforded by transverse sections of the petiole in the classification of the Eucalypts. The chief characters employed are those derived from the epidermis, hard bast, wood with its vessels, cortical cavities and central canal; they have found that each of the thirty species analysed has distinctive characters. But the tests employed appear to have been too limited; and before it can be admitted that such transverse sections are aids in the determination of species they should be applied to individuals of species living under diversified conditions. Even otherwise this histological system is too cumbersome in its application to be of diagnostic value.

INFLORESCENCE.

The usual condition is an umbel, but by lengthening of the axis passes to the panicle or corymb. The transition from one to the other is so easy, and often exemplified on the same tree, that it is

obvious that the form of the inflorescence is not reliable as a specific character. Bentham, however, says, "These peduncles with their umbels are, in their general arrangement, of some importance, constituting three types—(1) axillary or lateral, that is, solitary in the axils of the leaves or along the branches above or below the leaves; (2) several together in short simple panicles at the end of the branchlet or in the axil of the leaves; (3) in a compound terminal corymbose panicle; but these forms appear to pass into each other very much in imperfect specimens."

Useful specific characters are derived from the transverse outline of the peduncle or pedicel, such as terete, angular, compressed or winged; and in a few species the pedicels are abbreviated, as in *E. capitellata*, which distinguishes it from *E. macrorrhyncha*, both having fruits of the same shape.

GALLS.

"Mr. Bauerlen informs the author of his belief that species of Eucalyptus can be unerringly determined by means of the leaf-galls."—Maiden, "Useful Plants," p. 428, 1889. Mr. Froggatt, Proc. Linn. Soc., 2nd ser., vol. vii, p. 353, in the Notes on the *Brachyscelidæ*, which form woody galls on the twigs, leaves, and deforming the flower-buds, has, however, stated that "The members of the genus *Brachyscelis* are distinctly Australian, confining their attacks to the Eucalypts, and at one time I believed that each species of coccid had a partiality for a particular species of Eucalyptus; but observations extending over several years have proved that, though some of the rarer species may keep to one tree, most of them thrive on various Eucalypts."

FLOWER-BUD.

The operculum offers considerable diversity of form, and so far as I know it is very true of the species. It was first employed as a basis of classification by Willdenow, Sp. Plant., 1799, who grouped the twelve species then known into two sections according as the operculum was conical or hemispherical.

Don, 1832, also used the operculum in his subdivision of the species with alternate leaves. He recognised five distinctive shapes—(1) conical, longer than the calyx-tube, ex. *E. cornuta*; (2) conical, equal in length to the calyx-tube, ex. *E. stellulata*; (3) nearly conical or hemispherical, shorter than the calyx-tube, ex. *E. amygdalina*; (4) hemispherical, much broader than the calyx-tube, ex. *E. gomphocephala*; (5) depressed in the centre, shorter than the calyx-tube, ex. *E. globulus*.

The operculum is an important factor in the discrimination of species, and is largely availed of by Bentham in his treatment of the species in the "Fl. Austral.," and by Mueller in his "*Eucalyptographia*," the operculum of each species being pictorially represented.

ANTHERS.

Bentham, in "Fl. Aust., 1866," arranged the species into five primary sections according to the shape and dehiscence of the anthers, thus :—

1. Renantheræ.—Anthers reniform, large ; cells divergent at the base.
2. Heterostemones.—Outer stamens sterile; anthers globular, small, opening by pores or slits.
3. Porantheræ.—Anthers globular, small, opening by circular pores.
4. Micrantheræ.—Anthers globular, small, opening by lateral slits.
5. Normales.—Anthers globular, small, the cells distinct and parallel, opening by longitudinal slits.

Mueller, in his "*Eucalyptographia*," adopted the anthereal system of Bentham, but reduced the sections to four, and in the second edition (1889) of the "Census" three only are retained, viz. :—(1) Renantheræ, (2) Porantheræ, and (3) Parallelantheræ.

The species of Series 2 of Bentham are mostly transferred to Porantheræ. The elimitation of the characters dependent on the occurrence of anantherous stamens simplified the classification, and was desirable because the tendency to sterility of the exterior stamens belongs to all Eucalypts as to other polyandrous flowers. The presence or absence of staminodia may, therefore, be a feature of each individual flower.

The species of series 4 and 5 are comprised under Parallelantheræ.

Though it must be confessed that the anthereal system of classification brings into juxtaposition species allied in other respects, more so, perhaps, than any other system, yet persistency of anther-type is not always a certainty, and the manner of determination is a bar to its employment for primary classification. Moreover, the species are unequally distributed in the three sections. Thus, in the 1889 edition of the "Syst. Census Austr. Plants," series 1 contains 23 species, series 2 contains 14 species, and series 3 contains 96 species.

FRUIT.

There is obviously the need of an organ which exhibits greater diversity of form and structure and admits of a greater number of combinations than is afforded by the anther, or indeed any single structure as yet considered. The requirements seem to me to be best fulfilled by the fruit offering, for the most part, macroscopic characters, and the special advantage that it is nearly always possible to obtain them, whilst the flowering season is of limited duration and is not always of annual recurrence. At the same time, the characteristics are readily interpreted, needing no special

manipulation, as is required if we employ the anthereal system or that based on the histology of the petiole, or that on the chemical properties of the kinos and oils.

Bentham, "Fl. Austr.," iii, made only a minor use of the fruit character, but Baron von Mueller, "Syst. Victorian Plants," gave it a higher value. In my "Flora of South Australia" (1890) the thirty-three species inhabiting the province are primarily arranged, on the form of the fruit, into four sections, but the number of the divisions will admit of increase when dealing with the genus in its entirety.

I would now review the nature and value of the component elements embraced by a carpological scheme of classification :—

1. *Shape of Fruit.*—The shape to be described is that of a fully-ripe specimen, as immature states may prove delusive when testing the carpological system. In this connection Bentham, "Fl. Aust.," iii, p. 187, writes :—"It (the calyx-tube) often alters so much that it neither indicates the form it had in flower nor yet that which it will assume in the fruit." Thus in *E. pyriformis* the calyx-tube, on the fall of the operculum, is obconic, with a horizontal summit, but in the adult state it becomes biconic. Again, *E. cosmophylla* ranges from ovoid-conic in the early stages to hemispheric when mature.

The calycine portion of the fruit may extend beyond the capsular portion to varying heights ; its rim or margin may be acute, as in *E. Foelscheana*, or it may be of varying width, remain horizontal, as in *E. goniocalyx*, or become ascending with a convex slope, as in *E. capitellata*, or with a concave slope, as in *E. longifolia*, *E. pyriformis*, &c.

In the appended carpological schedule I have set forth the leading geometric forms assumed by the Eucalyptine fruits, so there is no need to describe them in this place ; but a fundamental investigation is that of the persistency of shape for each species. From my own experience, the shape of the fruit is constant within natural and reasonable limits. Thus *E. Foelscheana* is usually globosely urn-shaped ; but by contraction at the summit becomes globosely-oval—a natural transition. *E. capitellata* is usually biconic, but may become roundly depressed atop, thus passing to globulose or ovoid-conic. I do not find any variation of shape that does violence to a geometric development. If we except *E. incrassata*, following Mueller's interpretation of the species, here there is undoubted geometric discordance ; but the disassociation of *E. dumosa*, as adopted by Bentham, at once removes the anomaly ; indeed, the difference of fruit in conjunction with that of habit justify specific distinctions between them.

2. *External Sculpture and Ornament.*—Though the outer surface of the fruit is usually smooth, with a more or less circular

outline in transverse section, yet becomes prismatic in *E. goniocalyx*, axially ridged in *E. incrassata*, *E. pyriformis*, &c., or ornamented with asperities, as in *E. Foelscheana*.

3. *Capsular Teeth.*—In the larger number of campanulate and ovoid fruits the capsule is extensively overtopped by the calyx-tube—in these deeply sunken capsules the capsular teeth are usually included, but they are prominently exsert in *E. oleosa*, *E. salmonophloia*, whilst the obconic fruits must obviously have exsert capsular teeth. Apart from the exsert or included position of the teeth, their shape and length offer considerable variation, and may be usefully employed as minor distinctive specific characters.

4. *Capsule-cells.*—The number of the fruit-cells varies from three to six, and is not constant for each species, though a given number may largely prevail.

5. *Fertile Seeds.*—As pointed out by Bentham, the fertile seeds only differ from each other in being wingless or winged, and "that the wing when it exists varies remarkably in size and shape in different seeds from the same specimen." And though Baron F. v. Mueller, in his "*Eucalyptographia*," has depicted the seeds (fertile and sterile) for each, yet he does not utilise the apparent distinctions among the leading specific characters. I myself have thought it not worth the while to test the value of this structure.

It may now be concluded that by the employment of a carpological system in the classification of the Eucalypts, we have several factors available, which, taken in their varying combinations permit of a more detailed classification than is possible by the use of any other single structure; if to the fruit we add the characters afforded by the pedicels which usually can be found with the fruits, then increased means of discrimination are afforded.

The subjoined Schedule, giving the grouping of the species by carpological characters, can only be a tentative one, as, moreover, I have not the material by means of which the system might be most fully tested, and thus pursue the treatment of my subject towards a finality.

SERIES A.—Ovoid, medially inflated, attenuated below, truncated above the middle.

(1.) *Ovoid.*
Behriana
hæmastoma
populifolia
piperita
pauciflora
melliodora
obliqua
saligna
marginata
diversicolor
maculata
redunca
oleosa
patens
uncinata
salmonophloia
trachyphloia

(2.) *Ovoid-oblong.*
crebra
corymbosa
occidentalis
robusta
stricta
leucoxylon
punctata
Planchoniana
salubris
tetragona
buprestium
goniocalyx
Landsdowneana

(3.) *Ovoid-conic*, passing to Series Biconic.
amygdala
acmenoides
odorata
paniculata
largiflorens
santalifolia (pars)
capitellata (pars)
Gunnii

SERIES B.—Biconic.

1. Base elongate, longer than wide.
   Exs. longifolia, cornuta, gomphocephala.

2. Base hemispheric or ovoid, as wide as long—
   (*a*) Fruit very large, 2 or more inches diameter.
   Exs. pyriformis, macrocarpa.
   (*b*) Fruit medium-sized, ½ to 1 inch diameter.
   Exs. Oldfieldi, pachyphylla, capitellata.
   (*c*) Fruit small, under ½ inch diameter.
   Exs. macrorrhyncha, rudis, rostrata, decipiens, Stuartiana, tereticornis, viminalis, salubris.

SERIES C.—Globulose to hemispheric.

1. Globulose. Exs. Howittiana, stellulata, Todtiana, eugenioides.
2. Globulose-ovoid. Exs. doratoxylon, eudesmioides, salmonophloia, cneorifolia, capitellata (pars).
3. Hemispheric. Exs. cosmophylla, cordata.

SERIES D.—Ellipsoid, sides approximately parallel; length at least two times the breadth.

1. Ellipsoid, ridged.
   Ex. tetradonta.

2. Ellipsoid-obconic.
   (*a*) Base gradually attenuated. Exs. gracilis, diversicolor, microcorys.
   (*b*) Base more abruptly attenuated. Exs. fœcunda, hemiphloia, botryoides.
3. Ellipsoid-ovoid, slightly narrowed towards the summit.
   (*a*) Externally ridged. Exs. tetragona, ptychocarpa, corynocalyx, incrassata, clavigera.
   (*b*) Not ridged. Ex. gamophylla.

4. Ellipsoid-urn-shaped, slightly narrowed towards the summit, thence slightly dilated.
   (*a*) Smooth. Ex. phœnicea.
   (*b*) Ridged. Ex. clavigera.

SERIES E.—Campanulate, general outline ovoid-oblong, more or less dilated at the summit.

1. Urn-shaped, distinctly dilated at the summit.
   (*a*) Fruit 1 inch or more long. Exs. Foelscheana, Watsoniana.
   (*b*) Fruit under 1 inch long. (i) Fruit somewhat globulose. Ex. Baileyana. (ii) Fruit oblong. Exs. obcordata, eximia, peltata, tessellaris, terminalis (axially streaked).

2. Urn-shaped ovoid, not markedly dilated at the summit.
   (*a*) Fruit 1 inch or more long.
      (1) Longitudinally wrinkled. Exs. calophylla, sepulcralis, miniata.
      (2) Smooth. Ex. setosa.
      (3) Hispid. Ex. Foelscheana (pars).
   (*b*) Fruit under ½-inch long. Ex. pruinosa.

No. 12.—THE HOST PLANTS OF THE AUSTRALIAN LORANTHACEÆ.

By RALPH TATE, Professor of Natural History in the University of Adelaide.

(*Read Monday, January* 10, 1898.)

BENTHAM, Fl. Aust., iii, p. 388, 1866, writes:—"The notes of collectors on the trees on which the several species [of *Loranthus*] grow are so varied that there seem to be no evidence that particular species affect particular trees. The most commonly noted are *Eucalyptus, Casuarina* and *Exocarpus*, but *Acacia, Banksia, Melaleuca, Fusanus* and many others are also mentioned as feeding species of *Loranthus*." He refers to the host-plants of one species of *Loranthus* (*L. celastroides*), though the denominations of *Exocarpi*, *Casuarinæ* and *Melaleucæ* as applied to *L. exocarpi*, *L. linophyllus* and *L. pendulus* respectively imply the generic position of their host-plants. Mueller, Frag. Phyt., ii, p. 109, reports *Notothixos incanus* upon *Eucalypti* and *Angophoræ*, and Bentham, *op. cit.*, remarks under *Viscum* and *Notothixos* that, "they are found sometimes growing upon species of *Loranthus* as well as upon the trees that feed them."

Our knowledge of the life-histories of our Loranthaceæ was thus, at the date of publication of the third volume of the "Flora Australiensis," brief in quantity and indifferent in quality. Under these circumstances, I have thought a useful purpose might be served by bringing together additional facts as the outcome of field-observations by botanists and well-trained collectors; and by extended observations we may arrive at the conclusion respecting the restricted or non-restricted distribution of these parasites.

LIST OF AUSTRALIAN LORANTHACEÆ AND THEIR HOST-PLANTS.

Viscum orientale, Wild. No record.

V. angulatum, Heyne. No record.

V. articulatum, Burmann. On *Doryphora sassafras*, by F. Turner, P.L.S., N. S. Wales, ser. 2, vol. 9, p. 559, 1895.

Notothixos incanus, Oliver. On *Eucalypti* and *Angophoræ*, F. v. Mueller, Frag. Phyt., ii, p. 109; on Currajong *(Sterculia)*, Hamilton, P.L.S., ser. 2, vol. 2, p. 283.

N. subaureus, Oliver. No record.

N. cornifolius, Oliver. On *Sterculia diversifolia*, Baker, P.L.S., vol. 2, p. 452.

Loranthus celastroides, Sieber. The broad-leaved form on *Banksia* and *Casuarina*, the narrow-leaved form on *Eucalyptus* and *Casuarina*, Bentham, Fl. Aust., iii, p. 390; on *Eucalypti*, Hamilton, *op. cit.*

L. Bidwillii, Bentham. On *Callitris cupressiformis*, by Scortechini, P.L.S., N. S. Wales, vol. 8, p. 251, 1884; on *Callitris sp.*, Baker, *id.*, 1896, p. 452.

L. myrtifolius, Cunningham. No record.

L. longiflorus, Desr. No record.

L. angustifolius, R. Brown. [The original specimens and locality still remain unique; the host-plant is probably *Casuarina quadrivalvis* or *Melaleuca parviflora.*]

L. dictyophlebus, F.v.M. No record.

L. alyxifolius, F.v.M. No record.

L. odontocalyx, F.v.M. No record.

L. linearifolius, Hooker. I have observed this species very abundantly on *Acacia sp.*; the species has not been recorded, but I am almost sure it is *A. aneura.*

L. Murrayi, F.v.M. and Tate. On *Acacia aneura*, by Tate, Trans. Roy. Soc., S. Aust., vol. 6, p. 109, 1883; on *Acacia aneura* and *A. salicina*, by Elder Expl. Exped., idem, vol. 16, p. 360, 1896.

L. exocarpi, Behr. On *Acacia aneura* as a rule, but also on *Cassia Sturtii* and *Eremophila Freelingii*, Elder Expl. Exped., *op. cit.*; on *Casuarina quadrivalvis* and *Exocarpus cupressi formis*, (Herb., Adelaide University).

L. acacioides, Cuming. No record.

L. signatus, F.v.M. No record.

L. maytenifolius, A. Gray. No record.

L. sanguineus, F.v.M. No record.

L. bifurcatus, Bentham. No record.

L. linophyllus, Fenzl. On *Casuarina*, by Miquel (inferred); on *Casuarina Cunninghami*, by Woolls, P.L.S., N.S.W., vol. 2, 2nd ser., p. 1077 ; on *Acacia aneura*, by Elder Expl. Exp., *op. cit.* ; on *Acacia sentis* and on *A. tetragonophylla*, (R.T.) in Herb., Adelaide Univ.

Var. *parviflorus*. On *Callitris*, by Hamilton, P.L.S., N.S.W., ser. 2, vol. ii, p. 282. [The species of *Callitris* is either *verrucosa* or *columellaris.*]

L. gibberulus, Tate. On *Grevillea nematophylla*, by Tate, Trans. Roy. Soc., S. Aust., vol. viii, p. 71, 1886 ; on *Grevillea striata*, *G. agrifolia* and *Hakea leucoptera*, Horn Exped., pt. 3, p. 160, 1896 ; on *Hakea lorea*, Elder Expl. Expd., *op. cit.*

L. pendulus, Sieber. On *Melaleuca*, S. Aust. ; on *Eucalypti*, chiefly *E. rostratus*, and on *Casuarina quadrivalvis*, by R. Tate, in Herb. Univ., Adelaide.

var. *amplexifolius*. On *Brachychiton Gregorii*, Elder Expl. Exped., *op. cit.*

var. *canescens*. On *Acacia homalophylla*, Elder Expl. Exped., *op. cit.* ; on *Acacia aneura*, Herb. Univ., Adelaide.

var. *Melaleucæ*. On *Melaleuca ericifolia*, Tepper ; *Melaleuca parviflora* and *Myoporum platycarpum*, Herb. Univ., Adelaide; on *Melaleucæ*, implied, Pl. Priess.

var. *parviflorus*. On *Melaleuca styphelioides*, Maiden, *Agric. Gaz.* N.S.W., v. 615.

L. quandang, Lindley. On *Acacia aneura*, Tate, Roy. Soc., S. Aust., vol. vi, p. 103, 1883 ; Horn Exped., *op. cit.* ; Elder Exped, *op. cit.*

L. grandibracteus, F.v.M. On *Eucalyptus microtheca*, Horn Exped., pt. 3, p. 160, 1896.

REMARKS.

I am not disposed to attribute any particular adaptation of the host-plant to the requirements of its particular parasite, though it is significant that some species of *Loranthus* seem to have a predilection for a restricted group of plants—notably in the case of

L. gibberulus, which ranges in Central Australia over an area of not less than 30,000 square miles, and has hitherto been observed, and frequently so, only on Proteaceous trees and shrubs; whilst *L. quandang* occupying the same area is restricted to *Acacia aneura*. On the other hand, *Loranthus pendulus* was observed by me, some twenty years ago, to occur in some of the orchards about Adelaide indiscriminately on fig, apple, pear, and other fruit-bearing trees; of late years it seems to have died out, in all probability the agents of transplanting the seeds have, through closer settlement and other causes, been expelled the district.*

Some explanation of the attachment to certain mistletoes to particular host-species may be found when we shall have acquired full knowledge of the habits of the birds which are the agents of their dissemination. In the first instance, the association may have been accidental, some fruit-eating birds may have preferred certain species of trees or shrubs for shelter, and thus eventually there has arisen this phenomenon of interdependency—the tree affording food and as well as protection to the bird, and the bird securing the continuance of the species of mistletoe.

The only agent, at present known, playing this role in the economy of the *Loranthaceæ* is *Dicæum hirundinaceum*, concerning which in this connection, Dr. Ramsay, P.L.S., New South Wales, 2nd ser., vol. i, p. 1093, 1886, writes:—"This species is universally dispersed over the whole of Australia; feeds on berries and fruits of various kinds, but seems to prefer those of *Loranthus* ——; this plainly accounts for the distribution of the *Loranthus* and *Viscum* all over the districts frequented by the *Dicæum*, and in which it is locally known as the *Mistletoe-bird*." But both bird and mistletoe are absent from the large adjacent insular lands of Tasmania and Kangaroo Island. Dr. Ramsay has, however, included the bird in the geographical column for Tasmania, in his "Tabular List of Australian Birds," 1888; but this record is an error, as I am assured by the leading ornithologists in Tasmania.

An extensive tract of lightly-timbered country on the eastern slope of the Adelaide chain has also neither mistletoes nor *Dicæum*. The *Dicæum* is very partial to the white ripe berries of *Loranthus linearifolius*.

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* Mr. F. Turner, F.L.S., New South Wales, 2nd ser., vol. 9, p. 557, 1895, records 27 species of exotic trees and shrubs growing in New South Wales which are hosts for certain Australian Loranthaceæ, viz., *Loranthus celastroides*, *L. pendulus*, and *Viscum articulatum* the first two being much more common than the last.

No. 13.—ON THE METHODS OF FERTILISATION OF SOME AUSTRALIAN PLANTS.

By Alex. G. Hamilton.

(*Read Friday, January* 7, 1898.)

MONIMIACEÆ.

Palmeria scandens, F.v.M.—A straggling, semi-climbing, woody shrub. The male and female flowers are borne upon separate plants. It flowers in winter (May, June, and July). The males consist of a calyx of 4–5 connivent lobes, more often 5 than 4 (Fig. 1). The numerous anthers are sessile (Fig. 2), the pollen small and minutely granular (Fig. 3). The female calyx is almost globular (Fig 4), with a minute orifice at the top, out of which the filiform stigmas (6–8) protrude (Fig. 5). The fruit, when ripe, is dark reddish purple, and opens raggedly, disclosing the black shining drupes (Fig. 6). Both male and female flowers are pale green, and have a strong sweet scent. They are frequented by small pollen-eating beetles, which are always smeared with pollen, and doubtless it is by their agency that the flowers are fertilised. A large proportion of the females do not set seed.

VIOLACEÆ.

Viola hederacea, Labill.—The plants of the genus Viola have the five anthers closely surrounding the ovulary, the filaments being widened and clasping it. There is usually a hollow spur to the lowermost petal, in which in some species lie two spurs from the lowest filaments, these last acting as honey glands, and the sac as a receptacle for the nectar. Some species also have a little lid projecting in front of the stigma, so that when an insect inserts its proboscis, the lid moves downwards, and allows any pollen on the insect's head or thorax to reach the stigma, but as it withdraws the lid is closed up over the stigma, and so prevents autogamy (1, 2).

In the species under notice, the flowers are white with a purplish tinge, the two upper petals fold over backwards. The lateral and lowest petals have pathfinders pointing to a small hollow, scarcely a spur, in the lowest petal, which is green inside. There are no spurs on the lower filaments. The two lateral petals have patches of short papillæ at the shoulder, to aid insects in clinging to the nodding flower. There is no lid to the stigma. The ovulary is green, but with a patch of purple on each side, of

which I cannot see the significance, as it is hidden by the wide filaments. Although Australian violets are supposed to be scentless, this species is an exception, as on warm days, particularly when the air is moisture-laden, it has a very strong rich scent. The plants bear seed freely, but I have never seen them visited by insects. I have never found cleistogamous flowers on this plant.

Viola betonicifolia, Sm. The ordinary form of this flower is coloured purple, the lateral petals having a number of long, club-shaped hairs on the shoulder, and a row of similar hairs occupying the median line of all the petals. The lower petal is shortly spurred (Fig. 7), and two short processes (Fig. 9) project from the lowest filaments into this. There is no lid to the stigma, which is spheroidal. Another variety has a sac of about same size, but the filament spurs longer (Fig. 10). In a third variety, growing in a swamp at Guntawang, near Mudgee, the flower was pure white, with narrow purple lines pointing to the honey receptacle. This was very deep (Fig. 8), and occupied by very long processes from the lowest filaments (Fig. 11). This variety differed in no other but these particulars from the first two mentioned. Neither Hermann Müller nor Sir John Lubbock notices one function of the long projections of the filaments in plants of this genus, viz. : their action as levers on the stamens when an insect inserts its head into the nectary. It is very noticeable in the long-spurred variety described above. If the experiment be tried with a bent wire in this variety, it will be found that, as the wire reaches the bottom of the honey sac, the portion answering in position to a bee's head throws the spurs backward and apart, and a shower of pollen drops down on the wire.

Bees visit the flowers, which seed freely. I have not observed cleistogamous flowers in this species either.

EUPHORBIACEÆ.

Croton Verrauxii, Bail. A common shrub on the foot-hills, and flats, and in brush forests in Illawarra. From its strong aromatic scent, it is commonly known as "Cascarilla." Even the wood is strongly scented. For the most part it is monœcious, but there are variations in this respect. I have noted the following :—

(1.) Male and female flowers on separate trees.
(2.) Male and female flowers in separate racemes on the same plant.
(3.) Male and female flowers in the same racemes, the females below.

The young shoots are closely covered with stellate hairs, but the growth of the internodes and leaves separate them, so that later they seem widely scattered. In the young leaves there are glands

on the teeth of margin which secrete a sticky varnish to protect the tender epidermis. At the base of each leaf are two cushion-shaped glands with their secreting surfaces turned downwards; the secretion is very slight. In the autumn and spring months the old leaves turn a dull orange red, and, indeed, the young leaves show a good deal of the same tint.

The male flowers have petals and sepals, the inside of the flowers being filled, and the petals margined, with woolly hairs (Fig. 12). The stamens are twelve in number, and the anthers open extrorsely. The female flowers have usually sepals only, and there are no woolly hairs present (Fig. 13); the immature ovulary has a few minute stellate hairs on its surface. The stigma is deeply divided into six arms (Fig. 14). The lowest flowers in the racemes open first. But in some racemes bearing both males and females there are two sets of males. A number of those at the top will be found open and shedding pollen, while lower down there will be found a number of male buds, each above an open female. The pollen is large, with fine projections (Fig. 15), so that it is unlikely that the plant is largely wind-fertilised. I have never seen any nectar in either kind of flower, but they are very strongly scented. The young shoots are a good deal infested by a black aphis, and there is no doubt they are sometimes fertilised by the winged individuals of these, as I have seen them on both male and female flowers, and with pollen adhering to them. The ants run up and down the racemes, visiting the aphides, and no doubt also contribute to the fertilisation. Various species of Diptera and Hymenoptera frequent the blossoms to feed on the pollen. The native bee (*Trigonia carbonaria*) collects pollen from the blossoms. It is rare to find a female flower which does not mature seed, so that the means of fertilisation seem to be sufficient.

Baloghia lucida, Endl.—This tree grows freely in the brush forests in the neighbourhood of creeks in Illawarra. It is monœcious, the males and females growing on separate twigs. The flowers are white, and have a rich scent, exactly like that of *Sarcochilus olivaceus*, which grows in the same dark forests. Many insects, especially moths, are attracted by the scent and the honey which is secreted by the glands on the disc. The female flowers almost invariably produce seed. The fruits are eaten by the flock pigeons (*Lopholaimus antarcticus*), which void the seeds uninjured, and thus aid in the distribution of the plants.

SAPINDACEÆ.

Cardiospermum Halicacabum, Linn. "Balloon Vine."—This is an annual climber, of which Hermann Müller says that it is proterandrous (1, p. 164). It is markedly irregular in form, and would, therefore, appear to be adapted to insect visitors, and yet

I have never seen one on the flowers. This may arise, however, from the fact that it is not an indigenous plant, and the particular insects affecting it not being found here.* The sepals are greenish, and the upper one is hood-shaped. The inner petals form a tube, the lower two being thickened and yellow, with a scale on the inner side, and some hairs. The remaining petals are white, larger, and spreading. There are two nectar-secreting glands at the base of the tube. The tube of two petals encloses the anthers in the first stage, and the style is short and not seen. An insect visiting the flower for nectar, when in this stage, must insert its proboscis between the anthers, and so get dusted with pollen. After a time, the trifid stigma protrudes between the anthers, while the hood-like sepal moves down so as to cut off all access to the honey except through the tube. A pollen-dusted insect must, in this second stage of the flower, smear the pollen on the stigma. But if no insects should visit it, the anthers still retain pollen, and the stigma touches them as it expands, and also receives it from the hairs within the lip as it forces its way out of the tube. Thus if no insects work at the flowers, they will be self-fertilised. This is apparently what occurs at Mount Kembla in my garden, for every flower sets seed, and the plant springs up self-sown every year. In pollen taken from flowers in the first stage, very many grains had emitted short tubes from one, two, or three of the corners (Fig. 16).

THYMELEÆ.

Pimelea ligustrina, Labill., var. *hypericina*.—In a paper in the Journal of the Linnean Society (3) Mr. J. C. Willis describes the method of fertilisation of *P. decussata*, R. Br. (*P. flava* in "Flora Aust."). I find that in the species under notice fertilisation is effected in much the same way. The flowers grow in a dense globular head, those on the circumference opening first. The flower is 13 mm. long, with 4 perianth lobes 8 mm. across, the opening of the tube being 1·5 mm. The anthers, two in number, stand out at an angle from each other and shed pollen freely, the style and stigma being at this time hidden within the tube. Then the style grows out so that the stigma is about 2 mm. above the opening of the tube and about the same distance below the anthers. These now diverge slightly, but not to the degree observed in *P. decussata*. The flowers are sweet-scented in the daytime, but not at night. Insects visiting them are mostly those with long proboscides, and they probe the blossoms one after another, receiving pollen from the mature anthers and placing it on the mature stigma. They visit head after head on the same plant, and then fly to other plants, so that cross fertilisation is almost certain. From the position of the anthers when the stigma is mature, any flower is not

* It however occurs in Queensland and North Australia.—(Ed.)

at all likely to be fertilised with its own pollen. But as the anthers open in the central part of the head, their pollen must often drop on the stigmas of the outer flowers, especially as the heads nod. In this way fertilisation ensues between flowers of same head. The plant is a great favourite with insects. Among those frequenting the two shrubs in my garden were many *Hymenoptera*. The hive bees worked all over the heads, beginning at the outer edge, and collecting both honey and pollen, as did many small native species of the same order. Among *Lepidoptera* I noticed *Pyrameis itea*, Fab., *P. Kershawii*, McCoy, and some small day-flying moths. These travelled all over the heads, inserting their proboscides in every flower; they were usually well covered with the bright orange pollen. A species of *Agarista* also visited them. A small green hemipterous insect seemed to live entirely in between the flowers. Every flower in the heads set seed, and many seedlings are found round the plants, both in my garden and outside.

Since completing the above I have collected a variety of this plant with pistillate flowers only. In Moore and Betche's "Handbook of the Flora of N.S.W." this species is placed in the section having bisexual flowers, or rarely with the sexes showing slight indication of separation.

The leaves were rather thinner in texture than in a normal form, the flowers a purer white, and, on the whole, much more hairy. They were being visited by flies and small *Hymenoptera*, and many of the stigmas were smeared with pollen. Very many of the heads were maturing fruits.

ROSACEÆ.

Rubus rosifolius, Sm.—This shrub flowers and fruits at all times of the year. It is apt to produce variegated foliage, patches and lines of cream-colour appearing in the pale green. The large white petals are variable in number, 5–7, and it sometimes has completely double flowers. The stamens are in a ring round the carpels, and the anthers and stigmas mature simultaneously. The stamens are at first curved upwards towards the carpels, but later straighten out. All parts of the plant are beset with green capitate glands—even the carpels, and they persist on the ripe fruit, but are then golden yellow in the head, and crimson in the stalk. They secrete a resin which gives the whole plant its pleasantly aromatic scent. Honey is secreted in a groove between the anthers and the ovulary. The flowers are visited by bees and flies, which alight upon the ovulary, and work head downward all round. The flowers are fertilised in this way; but should no insects visit them, autogamy occurs, as the newly-opened flowers have pollen all over the stigmas. Every flower develops fruit.

CANDOLLEACEÆ.

Candollea (Stylidium) laricifolium, F.v.M.—The method of fertilisation in this species is much the same as that described for *C. serrulata* (4). It differs, however, in some minor points. There are some honey-glands in the interior of the calyx-tube, and the flowers are often half full of nectar. They are visited by hive-bees. When the flower first opens, the summit of the style is covered by the two anthers (Fig. 17), and on each side is a fringe of club-shaped hairs (Fig. 18). The anthers open and display the loose, dry pollen. When a bee visits the flower, it goes to the back, and when it inserts its proboscis it touches the irritable spot near the base of the style, and the latter flies over the gynostemium, striking the insect on the back of the thorax, or of the abdomen in small bees, depositing the pollen there. At a later stage, the connective of the anthers grows downwards, so that they are no longer in position to touch an insect, and the stigma rapidly becomes papillose, slightly sticky, and mature. When reflexed by the irritation of a bee, it flies over, and becomes charged with the pollen on the insect. The flowers (Fig. 19) have not the corona on the petals which is present in *C. serrulata*. The metamorphosed petal which bends over the tube (Fig. 20) differs from that in the latter species. The plant blossoms in September, October, and November, and usually affects swampy situations, although the finest plants I have ever seen were on a dry talus at the foot of sandstone cliffs, at Cooyal, near Mudgee.

In observing the visits of insects to this and many other plants, I was much struck by the number of hive-bees coming to it. In many other native plants also they do a very great deal of the work of fertilisation, and often drive away native insects. The manner in which native insects take to introduced plants, too, is worthy of observation. The hawk-moths, for example, continually resort to *Lantana*, *Lonicera*, and the citrus fruit trees, and in very large numbers, and many of the native *Hymenoptera* are regular visitants to garden flowers.

EBENACEÆ.

Diospyros Cargillia, F.v.M.—This, though properly a diœcious plant, is one of those which show a transitional state between diœcious and hemaphrodite flowers, or *vice versa*. The males have 16 anthers, and the ovulary is rudimentary, and acts on a honey-secreting gland. It is bright orange, and has no style or stigma. The females have 8 anthers, but they are imperfect and produce little or no pollen. In these, also, the surface of the ovulary secretes nectar freely. The flowers hang mouth downwards, and though not large, are very attractive to insects from their sweet

strong scent, and plentiful supply of honey. I have observed some trees near my residence, and found they are very much visited by butterflies, hive and other bees, beetles, flies, and thrips. The small green frog (*Hyla phyllochroa*), recognised the value of the plants as a feeding ground, for I saw numbers among the leaves on every tree. Among the *Lepidoptera* observed feeding on the honey were *Hypochrysops ignita*, *H. hecalius*, *Pyrameis itea*, *P. Kershawii*, and several of the Hesperidæ. All the trees I observed, bore fruit abundantly, the flowering season being December, and the drupes ripening the following May.

CONVOLVULACEÆ.

Convolvulus marginatus, Poir.—The flowers are small, and do not open very widely; they do not close entirely at night, and last two or three days. The colour is white, with no lines of colour as honey-guides. There is a ring of greenish-yellow glands at the base of the ovulary which secrete a small quantity of honey. The anthers dehisce laterally, or slightly introrsely; they bend over the stigma, which is almost at the same level. The bases of the filaments are broad with trichomes at the edge, which interlock, and so cut off small creeping insects from the honey. Self-fertilisation seems to be the rule, as the stigma is thickly coated with pollen from the time the flower opens, and unless removed by insects, this must fertilise the plant. It bears seed freely, and I have not seen any insects visit it.

AROIDEÆ.

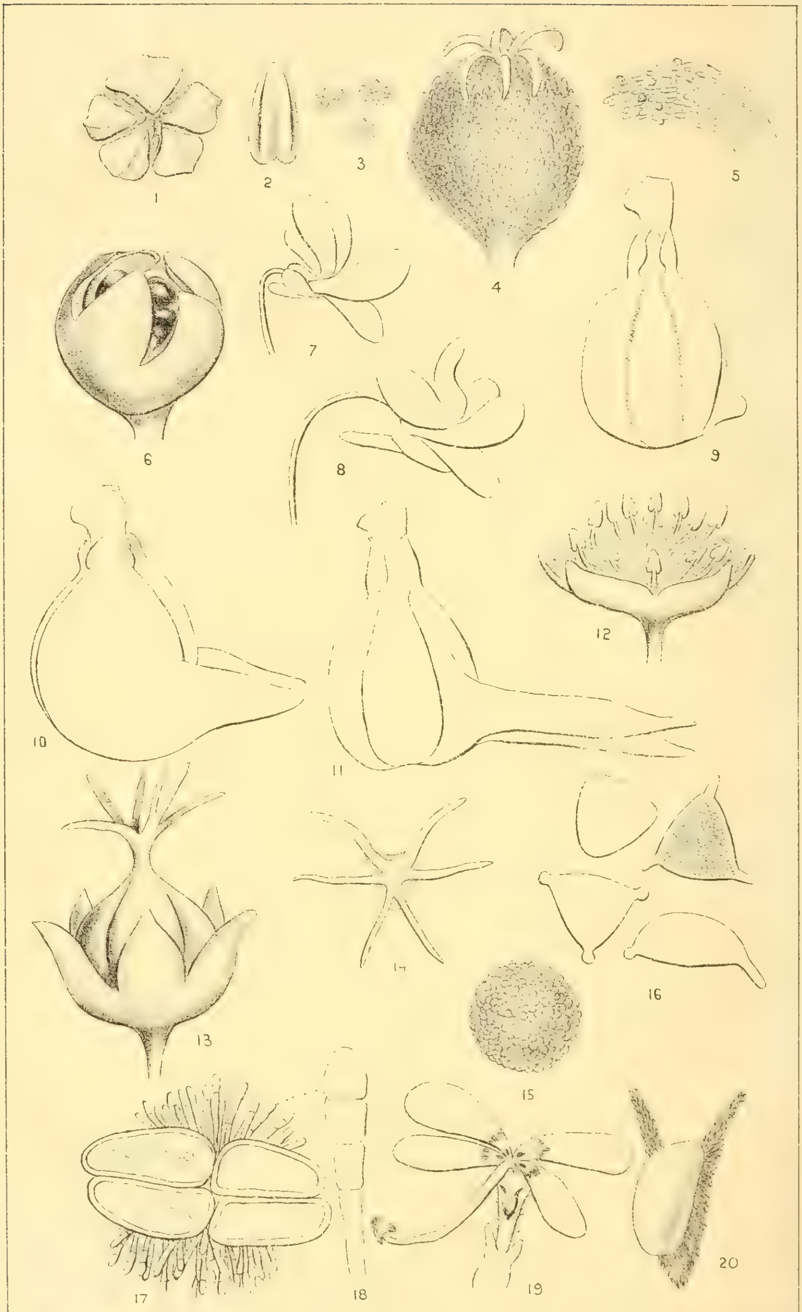
Gymnostachys anceps, R.Br.—The bisexual flowers grow in a close spike out of a small green spathe. Several spikes grow on one stem. The anthers are four in each flower, and are in opposite pairs. The flowers are protogynous, as the stigma emerges first, and is then, as far as I can judge, mature. Then the anthers appear and dehisce, but not simultaneously. It would seem as if the flower must be self-fertilised, or fertilised from pollen dropping from anthers higher up on the spike. Certainly it is not often that fruitlets are found on every flower; but, as they are very easily broken off at any time, that circumstance alone is not sufficient to judge from. The spikes are much frequented by spiders, and I have repeatedly noticed pollen on both the spiders and the web. I have also very often seen ladybirds travelling up and down the spikes, but was not able to make out their object in doing so. Flowers and fruit may be found almost all the year round, but the great period of production is the spring months.

Colocasia macrorrhiza, Sch.—The flowers in the spadix are unisexual, the females being in the lower part, and the males on the upper, and there is an intermediate space occupied by abortive stamens and pistils. The lower part of the spathe forms a chamber round the female flowers. In the first stage, the spathe and spadix are green, with a strong delicious scent resembling that of violets. At this stage it is visited by small beetles which Rev. T. Blackburn has been good enough to identify for me as *Brachypeplus Murrayi* Macl., these crawl into the spathe and feed on a liquid exuded by the pistils. The spathe then closes at the lower part round the females, so that nothing can get into the chamber. The upper part of the spadix turns dull orange in colour, and the free portion of the spathe white. The scent is now less powerful, and the anthers open and discharge quantities of dusty pollen. Beetles still visit the spathe, and become dusted with pollen; but, failing to make their way into the chamber, fly off to flowers in the first stage, and getting into the open chamber are shut up in it. In moving about, feeding on the liquid, or trying to get out, they deposit pollen on the stigmas. The beetles also eat the upper part of the spadix, and so are covered with pollen. When tired of their confinement they burrow out through the walls of the chamber. The leaves and spathe are attacked by the larvæ of a species of Agaristid, which hide in the chamber, in the axils of the leaf stalks, or in burrows which they excavate in the thicker veins. They come out at night to feed, and when alarmed drop by a thread and hang suspended. These also aid in fertilisation, as they are sometimes caught in the chamber, but always eat their way out after a time. The plants in my garden were also attacked by a large, very hairy larva, of a burnt sienna colour, and by the larva of *Chærocampa Oldenlandiæ*, which also attacked the plants of a taro plant close by.

While observing the flowers of *Colocasia*, I took some hundreds of thermometer readings in and about the flowers at all stages, but could detect no rise of temperature. Several observers have noted in some species of Aroidæ a rise varying from 10° to 47·75° F. above the air temperature.

I also made observations of the rate of growth of the flower stem from the time its first tip showed till it had reached the first flowering stage. These showed that the growth took place principally at night. The average growth during twelve hours of daylight was 5 mm., while the average during the night was 12 mm. The maximum night growth was 17 mm., and the minimum (the last night) was 4 mm. On very hot days the growth was much slower than on cool days. The total growth in 178 hours was 121·5 mm.

The sheathing leaf-stalks hold a considerable quantity of water after rain, which remains a considerable time. In one instance



Methods of Fertilization of some Australian Plants.

A. G. HAMILTON.

when filled, on the 15th December, there was still some water present on the 20th, and one had a small quantity on the 26th, although no rain had fallen in the meantime. The leaves on a plant grown in a moist, shady situation, reached the size of 5 feet by 4 feet, which is the greatest size I have seen them reach in the Illawarra district.

REFERENCES TO LITERATURE.

(1.) Hermann Müller, "The Fertilisation of Flowers," English edition, p. 117.

(2.) Sir John Lubbock, "British Wild Flowers in Relation to Insects," p. 58.

(3.) J. C. Willis, M.A., "Contributions to the Natural History of the Flower," Part II.; "Fertilisation-methods of various Flowers," J.L.S., Bot., vol. xxx, p. 284.

(4.) A. G. Hamilton, "On the Fertilisation of *Clerodendron tomentosum*, R.Br., and *Candollea (Stylidium) serrulata*, Labill, P.L.S., N.S.W. (2), vol. ix, p. 18.

EXPLANATION OF PLATE.

(1.) *Palmeria scandens*, F.v.M. Male flower, x 3.
(2.) Sessile anther, x 10.
(3.) Pollen grains, dry, x 125.
(4.) Female flower, x 5.
(5.) Tip of stigma, x 40.
(6.) Fruit, opening, nat. size.
(7.) *Viola betonicifolia*, Sm. Short-spurred flower, nat. size.
(8.) Long-spurred flower, nat. size.
(9.) Ovulary and anthers, short-spurred form, x 10.
(10.) ,, ,, medium-spurred form, x 10.
(11.) ,, ,, long-spurred form, x 10.
(12.) *Croton verreauxii*, Bail. Male flower, x 4.
(13.) Female flower, x 4.
(14.) Stigma from above, x 8.
(15.) Pollen, dry, x 250.
(16.) *Cardiospermum Halicacabum*, Lin. Pollen grains emitting tubes, x 250.
(17.) *Candollea laricifolium*, F.v.M. Anthers—first stage, x 10.
(18.) Hair from gynostemium, x 40.
(19.) Flower, x 2.
(20.) Altered petal, x 5.

No. 14.—NOTES ON THE FERTILISATION OF SOME NORTH AUSTRALIAN PLANTS.

By N. Holtze.

(*Read Tuesday, January* 11, 1898.)

Before entering upon the description of the mode of fertilisation of a few Australian wild flowers, I think it well to state the standpoint from which I pursue my inquiries. I hold it to be a fundamental principle that among all the different species of any one genus there will be found of necessity a strong family likeness in the mode of fertilisation, modified from the type in whatever degree to serve some particular need. Just as there is a resemblance in the flower among the species of any one genus, so will there be in the mode of fertilisation and in the modification of organs to that end. And this indeed is only what can be expected on the theory of descent from an ancestor common to them all. Thus the sensitive column with the fusion of stigma and stamens common to the different species of Stylidium can only be explained as being derived from an ancient form, the progenitor of all the present day species, and if these are examined in that light and the mode of fertilisation described in its variation from the type, or what may be considered as such, the interest and usefulness of the inquiry will be much enhanced. Holding the views I do, I regret that in this paper I am only able to describe a few isolated cases among the genera examined by me.

Grevillea chrysodendron, R. Brown.

The showy flowers of this species are closely packed into the form of a brush, and abound in nectar. Before maturity the long pistil is curved so that the stigmatic point is inserted between the anthers at its foot. At maturity the pistil becomes erect, bearing on its head the pollen deposited there by the anthers. The tree is visited by a small bird for the nectar in the flowers, and the pollen is taken from tree to tree on its breast and head, which come into contact with the stigmas in probing for the nectar. Cross-fertilisation, therefore, is facilitated, and the existence of the provision for the pollen being deposited naturally on each stigma would lead one to expect that in the ancestral form this was to insure fertilisation should the flower not receive pollen from elsewhere. However, in the species under notice, the flowers appear to be incapable of fertilisation with their own pollen.

Scaevola Koenigii, Vahl.

If a flower bud is cut open and examined the indusium will be noticed in the shape of a cup with fringed edges, above the immature anthers which, however, growing more rapidly than the pistil, soon overtop the indusium and appear round it with the pollen agglomerating into a mass which of its own weight falls into the indusium, or is caught by it in its upward growth brushing past the anthers. The sides of the indusium now contract and flatten, and the indusium curves over the passage to the nectar, and is in appearance just like a flat brush held over the passage, and which, if brushed against by an insect, deposits pollen on its back, the pollen being gradually pushed out to the fringing hairs by the growing stigma. The stigma eventually grows through the brushlike fringe, and is ready to take off pollen from the back of insects visiting the flower. As in the case of Grevillea chrysodendron the ancestral form of the order seems to have derived the indusium with the deposited pollen for the purpose of insuring self-fertilisation, if it failed to be fertilised by an insect visiting it with pollen from another flower; moreover the pollen also would be safe from pilferers.

Goodenia purpurascens, R. Brown.

The description of the fertilisation of Scaevola Kœnigii applies perfectly to this species, with the exception that only the lower lip of the indusium bears a fringe of hairs, and that the indusium is concealed from view by two of the petals when the flower is open.

Stylidium.

I have been able to examine three or four unidentified species of this curious genus. In all these the column bearing the stamens and stigma is sensitive and curved back above the passage to the nectary. The stamens appear first at the head of the column, and later on the stigma takes their place. An insect, in proceeding to the nectary, must touch against the lower part of the column, which rapidly springs forward, and, with the upper portion bearing either the stamens or stigma, strikes the insect on the back, at the same time closing the passage to the nectary. The act of striking the insect with the head of the column either leaves a deposit of pollen on its back or else takes up what pollen it had there from another flower, as the case may be, dependent upon the organ that is in evidence at the time. After a short period the column is gradually brought back to its original position, and, as it were, the gun is ready cocked for another visitor. The process is a beautiful one to watch and exact in its purpose, and, as in the case of Goodenoviæ, may have been evolved to save the

pollen from being misappropriated. I have not seen any species of Levenhookia; but from the description given in "Bentham's Flora," should imagine that the insect, instead of being struck by the column, is dashed against it by the sensitive labellum, and the flower thus fertilised. In any case, the insect is to be pitied for its rough reception.

MIMULUS UVEDALIÆ, Bentham.

The stigma in this species is in the form of two flat plates joined at the lower end, one plate hanging down over the passage in the flower and in advance of the two pairs of anthers. This plate is sensitive, and, touched ever so lightly, flies up and closes against its fellow. An insect coming into the flower would brush against the hanging stigmatic plate, which would sweep along the insect's back and close in the manner described. The insect, therefore, on leaving the flower with pollen on its back, could not deposit any on the stigma; while if it had any on its back on its first entrance, the hanging stigmatic plate would have swept it up and the flower been fertilised. After the lapse of a few minutes the sensitive plate resumes its original hanging position in the passage within the flower. Fertilisation by its own pollen, therefore, becomes very improbable while cross-fertilisation is favoured.

DOLICHANDRONE FILIFORMIS, Seemann.

The form of the flower and the disposition of the essential organs is exactly that of *Mimulus Uvedaliæ*, described above, and cross-fertilisation is favoured in the same way. The stigmatic plate is, however, not nearly so sensitive.

While on this subject I cannot refrain from departing from the title of my paper, and noticing a few plants which are not Australian. It would seem rather peculiar that two genera so widely sundered by systematists, as *Mimulus* and *Dolichandrone*, should both possess a stigma identical in form and also sensitive. The sensitive stigma is, however, not limited to these genera. I have examined a considerable number of species of the following genera, viz.:—*Martynia*, *Torenia*, *Tecoma*, *Bignonia*, and *Kigelia*, and all possess a more or less sensitive stigma, identical in shape and position. The anthers are also placed in the same relative position, and the form of the flower is the same.

I can conceive a plant losing one or more characteristics, and, perhaps, acquiring others; but for a great number of species to acquire many identical characteristics I cannot deem possible. To my mind, the only explanation possible is that the genera I have mentioned, as well as *Mimulus* and *Dolichandrone*, derive the sensitive stigma and other family features from an ancient

progenitor common to them all. I have no doubt that a large number of allied genera, if examined, will be found to possess the sensitive stigma, while others may have lost the sensitiveness, retaining, however, other characteristics. *Hemigraphis colorata* possesses features in common, but the stigma is altogether differently shaped, being composed of two narrow, thread-like pieces, the lower being much longer than the upper. The position is the same as in *Mimulus*, and, when touched, the lower piece curves up out of the way, after taking up what pollen there may be on the insect's back.

No. 15.—PECULIARITIES OF THE FLOWERS OF THE ORDER PROTEACEÆ.

By John Shirley, B.Sc.

(*Read, Tuesday, January* 11, 1898.)

In the "Flora Australiensis," vol. v., p. 316, speaking of peculiarities in the stigmas of these flowers, Mr. Bentham says: "The diversified mode in which in different genera the conformation of this style-end, and its relation to the anthers, promotes the dissemination of pollen, whilst it impedes self-fertilisation, upon which I have drawn up a few notes for the Linnæan Society, founded on the examination of dried specimens, would be an interesting study for local botanists who have the means of examining and watching the plants living in their native stations."

The paper to which Bentham refers was published with two plates in the Journal of the Linnæan Society, Botany, vol. xiii., pp. 58–64, and is entitled "Notes on the Styles of Australian Proteaceæ." It does not deal with the modes of fertilisation, the protection against useless insect visitors, or the peculiarities of the perianth; and his remarks are limited to eight of the thirty-three Australian genera.

Although fairly conversant with current Australian botanical literature, with the exception of Bentham's, I have not yet met with any notes on the fertilisation of flowers of this interesting family, and am therefore led to place on record the following observations on Proteaceous flowers and their visitors.

Mr. Scott Elliot, author of "The Naturalist in Mid-Africa," in Annals of Botany, May, 1890, p. 274, quotes *Protea incompta*, *P.*

mellifera, *P. lepidocarpon*, *P. longiflora*, *P. grandiflora*, *P. cordata*, and *P. scolymus*, with *Leucospermum conocarpum*, and *L. nutans*, as fertilised by birds, naming *Promerops caper*, and *Nectarinia chalybea* as the fertilising agents. In Annals of Botany, August, 1891, the same writer gives *Leucadendron adscendens* and *Serruria congesta*, as fertilised by *Apis mellifera* and other hymenoptera.

The Proteaceæ have their chief seats in Australia and South-west Africa ; but extend on the one side to New Caledonia, the Indian Archipelago, and through eastern tropical Asia to Japan; on the other side to South America. They are specially adapted for arid climates, where a short rainy season alternates with a long rainless period. Their leaves are furnished with breathing pores situated at the base of cavities in the lower surface of the leaf, and over-arched by cuticular or epidermal structures. The substance of the leaf is very tough and dense, and there are brick-like layers of corky tissue surrounding the cavities. The upper cuticle is usually of two dense cellular layers, beneath which is a close layer of palisade cells.

Since the Proteaceæ are inhabitants of desert regions, where in long droughts even insects may be destroyed, they are frequently furnished with a special pollen-storing apparatus, in order to effect fertilisation and set their seed; and that this apparatus often fails is seen in the few perfect fruits on Hakea and Macadamia bushes which have borne masses of blossoms, and by there being seldom a dozen fruits on a Banksia cone which carried a thousand perfect flowers.

In this order the flowers have only one protective and attractive coat, a perianth, formed of four leaves; the anthers are usually inserted in a sessile manner on the tips of the four petals, or are very shortly stalked. The style is long, and the stigma frequently remains hooked in the tips of the petals long after the style has forced its way through the perianth. At this stage the style looks like a single vase-like handle to the perianth from which it has escaped. When the stigma is free the style straightens itself with a spring and becomes erect. The substance of the style is exceedingly horny and elastic, especially in Banksia. The stamens ripen before the petals separate, and when the stigma is freed its under edges are covered with pollen. Naturally one would expect that self-fertilisation was the rule in Proteaceæ, but such is not the case. These flowers are protandrous, the stamens ripening first, and the stigma is not only immature when its companion stamens dehisce, but also when it rises erect covered with pollen, and for some time afterwards.

At the base of the ovary, or of the stalk on which it is supported, there are nectaries, consisting of annular, lunar, or wart-like glands; these play an important part in the life-history of

the plants in attracting suitable insect guests, and in preventing others from visiting undesirable spots, or in guiding insects along such tracks only as will best serve to promote fertilisation.

The reason why one species requires an annular nectary shutting the sexual organs off from insects crawling from below, while others possess an opening through the nectary, deserves further study.

The genera of this order divide naturally into two sections; in the first section are included all those plants in which the style is much longer than the perianth, and is consequently much protruded; to this section belong Banksia, Hakea, Grevillea, and others; in the second section the style is not much longer than the perianth, and almost wholly covered by it when the perianth has expanded, as in Persoonia, Conospermum, and Synaphea.

As an example of the long-styled orders, Grevillea may be taken. The flowers of the beef-woods are usually long, narrow, and irregular. The style usually protrudes by its middle from a slit in the perianth, its end being held fast, in the middle of the anthers, by the still coherent tips of the perianth lobes; but at this stage the stigma is immature. When the style-end is freed it rises covered with viscid masses of pollen. These masses gradually dry and fall away, or are brushed from the style-end by visitors—either birds or insects. If examined at this stage the style is found to be without a canal for pollen tubes, and there is no stigmatic tissue at its tip. An examination of transverse sections of the base of the style shows that the cavity of the style first develops there, and that its inner surface is clothed with cells resembling those of stigmatic tissue. This tube is gradually developed from the base upwards, and when it reaches the style-end, then, and then only, is a true stigma formed, and the flower becomes capable of fertilisation.

Although the structure of the style of Proteaceous plants has much in common with that of normal forms, the tip, before the growth of the style canal is completed, is lined within with peculiar, large, thick-walled, dotted cells, probably a nutritive tissue absorbed by the lining tissue of the style-tube, and whose functions are worth further investigation.

In a spike of Grevillea flowers the lowest have styles with a true stigmatic surface. The central ones have immature styles coated with pollen. The apical ones are still hooked in the perianths, and, where the style-end is adherent to the petals, are clothed round the line of attachment with a copious supply of honey. Parrots and honey-eaters frequent the plants at this and earlier stages, clinging below the flowers, and reaching to the apex of the inflorescence where most honey lies. In doing so they brush the pollen from the central flowers on their feathers, and, visiting the next branch, attach the grains to the lower stigmas of the next inflorescence, thus fertilising them.

As an example of the short-styled genera we may take Persoonia. Plants of this section are commonly known as "geebungs." The perianth is usually of four equal segments, and the stamens are on short filaments. At the base of the ovaries are four glandular nectaries. These glands persist after the petals have fallen, and are often visited by ants, which ascend the stems from below; but they seldom advance beyond the nectaries. These organs, therefore, act as barriers to useless insects, by furnishing them with food before they reach the sexual organs.

From above, these flowers are visited by species of *Diptera*, *Hymenoptera*, and *Lepidoptera*, and the whole of this section is entomophilous. Before the perianth lobes fall away they act as landing stages for flying insects. These visitors then become sprinkled with pollen from the shortly-stalked anthers. The next flower visited may have lost its petals, but the nectaries are still exuding honey, and the flowers, therefore, are still attractive to insects. The pollen-sprinkled visitor finds no petal platform to rest upon. Its only landing-stage is the style, and this is now in a receptive stage, and fertilisation is readily effected.

No. 16.—QUESTIONS CONCERNING THE TEMPERATURE OF PLANTS.

By W. Soutter.

(Read Tuesday, January 11, 1898.*)*

[*Abstract.*]

Respiration exists among all plants, although it is much more pronounced among young vigorous growing ones than those that are full-grown and matured. Plants respire, consequently they generate heat. The respiration in plants, as in animals, is caused by an absorption of oxygen and a combination of that gas with the tissues of the plant by which heat is produced. A series of experiments of a most minute nature has proved that a close correlation exists between the amount of oxygen supplied and the amount of heat generated. If oxygen be entirely withheld from

a flower, by placing it in inert gas from which all oxygen has been expelled, its temperature will fall to that of the surrounding atmosphere.

Among the many plants which I have experimented with, that which yielded, amongst others, very marked data is the bamboo (*Bambusa arundinacea*) the part of this plant experimented with being the young growing shoots. As is well known this plant grows with startling rapidity during the growing season. Let me for a moment say that I have for years tested, with mathematical precision, a twenty-four hours' growth of *Bambusa*, and on thirty-seven occasions found that during a period of twenty-four hours an upright growth of over 19 inches; on sixty-nine occasions over 14 inches; and 111 occasions over 12 inches. In 1893 the record growth in twenty-four hours was 25 inches. This was subsequent to a very heavy thunder-shower which was accompanied by an intensely high temperature of the air. The experiments carried out with the temperature of the bamboo was as follows:—

Max. dry bulb, external on Bamboo.	Max. wet bulb.	Max. inserted.	Min. External.	Min. inserted in young hoot.	Min. inserted in old wood.
89·0	80·1	90·2	72·4	73·3	72·5
88·5	80·6	91·0	75·1	78·8	75·5
87·6	79·8	89·9	75·2	78·0	75·8
87·2	81·1	90·0	76·1	79·1	76·6
86·6	81·0	89·4	71·0	78·8	72·0
85·8	76·5	89·3	72·8	75·8	73·1

The foregoing six readings are given to illustrate the fluctuation of the records. It must, however, be remembered that the readings of the wet bulbs and those inserted being practically under the same conditions, the comparison is of the most value. So much for the bamboo. Let us now turn to a plant of a very different structure, viz., *Musa* (banana), of which a six days' readings (consecutive) are given:

Max. in Shade, External (dry).	Min. in Shade, External (dry).	Max. Wet, External.	Min. Wet, External.	Max., inserted in Stem.	Min., inserted in Stem.
86·4	78·1	77·0	76·3	80·0	77·1
85·5	70·0	80·1	68·4	84·2	79·4
87·1	69·3	84·4	61·5	88·8	66·2
87·2	69·3	65·3	66·0	90·0	75·1
88·0	66·1	79·8	65·1	89·6	74·1
85·5	64·4	86·6	63·8	90·0	75·4

We shall now turn attention for a moment to consider the conditions obtaining in a fruit, the subject selected being a pumpkin. Absolute shade was the condition under which the experiment was conducted. A thermometer attached to the surface of the fruit gave readings as follow on six consecutive days :—

Max. Dry.	Max. Wet.	Min. Dry.	Min. Wet.	Max. inserted.	Min. inserted.
85·3	78·4	70·0	68·3	86·1	76·3
84·4	79·6	69·3	63·1	85·3	76·0
81·6	79·0	69·0	65·2	83·2	73·2
83·2	74·6	67·5	64·6	85·1	69·1
84·1	77·1	66·1	63·2	86·1	68·0
80·2	78·4	68·3	64·0	81·2	66·6
External.			Internal or Inserted.		

Flowers of plants exhibit the presence of considerable heat. These, of course, no doubt vary considerably in degrees according to size and substances. The flower experimented with by the writer was that of the night flowering Cactus (*Cereus grandiflora*). The tests were carried out during the night. A thermometer inserted into the unexpanded flower-bud gave a reading of 76·8 degrees Fah. as against 65·9 degrees Fah. of the surrounding atmosphere; this reading was taken at 6 p.m. A thermometer inserted at the base of an expanded flower, gave a reading of 77·3 degrees Fah., and 75·8 degrees Fah. ; these records were taken at 11 p.m., and 5 a.m., respectively. At the same hours the atmospheric readings were 66·6 degrees Fah., and 66·0 degrees Fah.

Another subject which possesses a great amount of interest, is that of the generation of heat by germinating seeds, the subject selected was a cocoanut. Two nuts were selected and put into a dry box, without soil, and placed in a room ; into one of the nuts was inserted a thermometer, while another was laid on the nuts. For ten days the readings were regularly taken, with the result that the inserted thermometer consistently registered 6·3 degrees Fah. lower than that of the surrounding atmosphere ; on the eleventh day the nuts were removed and placed in moist soil, and good germinating conditions supplied, absolute shade being afforded. A thermometer was inserted in the soil alongside the nuts; one was also inserted in one of the nuts, and another suspended immediately over the nuts. For the first eighteen days there was no perceptible rise in the temperature of the nuts, the heat fluctuating between 47·7 and 49·9 degrees Fah., with an atmospheric reading of from 68·0 to 75·0 degrees Fah. On the nineteenth day there was a visible rise of temperature of the nut, which continued to gradually rise for the next twenty-eight days, when the

experiment was abandoned. The following are the maximum readings of the three thermometers for the period mentioned.

Day.	Soil.	Nut.	Atmosphere.	Day.	Soil.	Nut.	Atmosphere.
	Fah.	Fah.	Fah.		Fah.	Fah.	Fah.
19	50·2	50·9	70·2	33	54·1	62·0	76·4
20	50·2	50·9	68·0	34	54·1	63·6	75·1
21	50·3	51·4	69·8	35	54·6	65·1	77·4
22	51·0	51·8	71·1	36	54·1	66·5	71·9
23	51·1	52·2	69·4	37	54·1	69·1	70·1
24	51·4	52·8	74·1	38	54·6	71·4	75·3
25	51·4	53·7	74·4	39	54·7	73·0	74·2
26	52·0	54·4	68·8	40	54·9	76·1	75·1
27	52·1	56·0	71·1	41	54·9	77·2	71·0
28	52·6	56·9	76·6	42	55·4	77·3	73·1
29	53·3	58·0	76·0	43	56·4	79·8	72·6
30	53·3	58·6	74·4	44	56·1	81·0	74·4
31	53·6	59·7	70·3	45	56·6	81·6	70·1
32	54·0	60·6	79·0	46	56·6	83·0	70·6

It is to be regretted that the experiment ended here, but circumstances prevented further investigation at that time. Numerous other interesting data could be given which might be worth recording, but enough has been said to induce some one to still further carry out experiments with regard to the generation of heat in plants. Science has recently offered to investigators "Electro thermo. needles," which should be of immense assistance in determining temperatures much more minutely. The instruments used by the writer in his researches were, in several instances, very inferior to those now procurable. Still the data secured are, in the main, reliable, as the instruments used were tested by a Kew standard thermometer, and corrected accordingly.

No. 17.—ON THE GROWTH OF VEGETAL GALLS.

By W. W. Froggatt.

(*Read Saturday, January* 8, 1898.)

ZOOLOGICAL PAPERS.

THE PROPOSED BIOLOGICAL STATION AND FISH HATCHERY NEAR DUNEDIN, NEW ZEALAND.

Letter from Mr. G. M. Thomson to Captain Hutton.

(*Read Tuesday, January* 11, 1898.)

Dunedin, 31st December, 1897.

Dear Captain Hutton,

It will, no doubt, interest the members of the Australasian Association for the Advancement of Science, and especially its Biological Section, to hear an account of the steps which have been taken in Dunedin to establish a Marine Fish Hatchery and Biological Station. I had hoped to make this communication in person, but have not been able to get away to attend the meeting in Sydney. However, I have much pleasure in making the facts known through you.

The question was first mooted by me in a paper read before the Otago Institute, on 8th October, 1895, entitled "On New Zealand Fisheries and the desirability of introducing new species of Sea-fish," in which the suggestion was made that, before any further legislation was proceeded with in connection with the fisheries of the colony, systematic observation on the habits and life-histories of the local species of fish was needed. In order to accomplish this, I suggested the establishment of a Marine Biological Station, which could further be utilised as a hatchery for such species of valuable fishes as it might seem desirable to introduce from other parts of the world. Correspondence with Dr. Fulton, of the Scotch Fishery Board, led us to believe that it might be possible to introduce either live fish or ova from a distance. The Otago Institute was sufficiently impressed with the apparent feasibility of the plan to appoint a Committee to look into the question during the summer of 1895–96, and especially to examine and report on Otago Harbour and its neighbourhood as to its suitability for such an establishment. The Committee reported, in May of the following year, that a most suitable site was obtainable at the entrance to

Purakanui Inlet, about 12 miles north of Dunedin. The reasons given were as follows :—

(1) Its ready accessibility from Port Chalmers, so that a small steamer could run round in little over an hour, while on the land side it is within three miles of a railway-station.

(2) Its sheltered position, so that, from whatever quarter the wind blows, the buildings would be safe from any sea, while at the same time a small steamer could lie close in to the entrance and be communicated with by boats.

(3) The firm and rocky nature of the ground which would greatly facilitate the erection of tanks, buildings, &c.

(4) The abundance of pure sea-water which would always be available.

(5) The fact that the inlet communicates with a wide bay—Blueskin Bay—into which, owing to a sort of eddy, great quantities of pelagic organisms are floated by the prevalent winds and currents, so that it constitutes an excellent feeding-ground for young fish.

(6) The occurrence of a current which flows up the coast in a north-easterly direction, at an average rate of about 1½ miles an hour, by which any fry liberated at Purakanui would tend to be distributed along the coast. This last point is important in a colonial point of view, for any fry set free in Otago waters would soon spread northwards; whereas, if they were liberated in the north, say, at Cook Strait, they would not readily, if at all, move southwards. From Purakanui, it would be a matter of simplicity to convey fish or fry to Foveaux Straits, or to Stewart Island.

The Institute adopted the report, reappointed the committee, and authorised me to communicate further with Dr. Fulton as to the possibility of retarding the development of fish ova for such a length of time as would enable them to be brought out to New Zealand without impairing their vitality. As an outcome of this correspondence, the Council of the Institute voted a small sum of money to recoup the cost of a series of experiments to be carried out by the Scotch Fishery Board, at their Dunbar Station, on this problem, during the summer of this present year. I hope soon to hear that these have resulted satisfactorily. Meanwhile, the question was kept before the public and the local members of Parliament, and at the beginning of this year the Council of the Otago Institute, and the Committee of the Otago Acclimatisation Society, each voted the sum of £250, conditional on the Government granting £500 for the work, and undertaking to carry on the

station for a few years. Within the last few days I have learned that Parliament has voted the sum asked for, and we, therefore, hope soon to be in a position to commence the erection of the necessary buildings.

What we propose to do as soon as these are ready is to commence observations on our local fish fauna, as well as on the hydrographical conditions which prevail here, and with regard to which there is no information at present available. Then should the result of the experiments at Dunbar prove encouraging, we hope, in 1899, to commence the introduction either of individuals or ova of the Turbot and the Cod (*Gadus morrhua*), and, if possible, of the home Herring. Specimens of the true Lobster (*Homarus*) were liberated some few years ago at the mole at the mouth of the Otago Harbour, but it is extremely doubtful whether the locality was suitable, and no evidence has yet transpired as to the success or otherwise of the experiment. But there is no difficulty, beyond that of expense, in bringing out more of these valuable crustaceans, and if they were kept in confinement in suitable enclosures, the chances of their fry being liberated, and successfully distributed, would be much increased. The same remark applies to the edible Crab of Britain, which we also intend to experiment with.

I hope that at the next meeting of the Association it will be possible to present a report of the work done at the Purakanui Fish Hatchery, and, meanwhile, we would be glad of the sympathy and co-operation of the Association.

I remain, &c.,

GEO. M. THOMSON.

No. 1.—NESTS AND EGGS OF THE HONEY-EATERS OR MELIPHAGOUS BIRDS OF AUSTRALIA.

By A. J. Campbell.

(*Read Saturday, January* 8, 1898.)

Encouraged by the appreciation of my former articles "Eggs of the Australian Breeders of the Plovers, Sandpipers, &c.," and "Nests and Eggs of the Australian Diurnal Birds of Prey," I have ventured to give, at the Sydney meeting of the Congress, a complete treatise on "The Nests and Eggs of the Australian *Meliphagidæ*, or Honey-eaters"—a family of birds numerous,

varied, and perhaps the most attractive of the Australian avifauna. I have followed the classification and nomenclature of the British Museum, omitting the genus Zosterops.

Myzomela sanguinolenta, Latham.

"Blood Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 63.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 131.

Previous Descriptions of Eggs.—Ramsay—Ibis, vol. i, new ser. (1865); Campbell, Southern Science Record (1883).

Geographical Distribution.—Queensland, New South Wales, and Victoria.

Nest.—Cup-shaped, small, neat; somewhat scantily constructed of strings of bark without any other lining; usually suspended in a bush or among the topmost branches of a Melaleuca. Interior dimensions, $1\frac{1}{2}$ inches across by 1 inch deep.

Eggs.—Clutch, 2–3; roundish in shape; texture very fine; surface slightly glossy; colour, warm or pearly white, marked chiefly about the apex with blotches and spots of dull chestnut and grey. Dimensions in parts of an inch of a clutch (1) ·64 x ·49; (2) ·61 x ·47.

Observations.—This small and bright blood-coloured Honey-eater has an eastern habitat, ranging almost from Cape York down to Eastern Victoria.

In Northern Queensland my companions and I enjoyed watching scores of these beautiful little birds, with shining scarlet head and neck, disporting themselves and feeding among the Melaleuca blossoms, especially on dewy mornings. We did not succeed in finding a nest.

However, I was indebted to Dr. E. P. Ramsay for a pair of eggs, and his description of the nest I have used. Dr. Ramsay observes that the Sanguineous Honey-eater arrives in the neighbourhood of Sydney during the months of October and November, remaining to breed during November and December, and as late as January.

The first Blood Honey-eaters noticed in Victoria, which are in the National Museum, Melbourne, were shot by Mr. C. J. Stafford in Gippsland. By way, I may mention that Mr. Stafford was a mate of the late Mr. H. W. Wheelwright ("Old Bushman"), who wrote "Bush Wanderings of a Naturalist."

Mr. F. Hutchinson sent to the *Australasian* office for identification a sketch of a pair of Blood Honey-eaters, which were observed feeding among the blossoms in his garden, Alexandra, Victoria, 22nd September, 1896. The beautiful birds were interesting visitors indeed, being so far out of their usual track, and so early in the season.

MYZOMELA ERYTHROCEPHALA, Gould.
"Red-headed Honey-eater."

Figures.—Gould, Bds. of Australia, fol., vol. iv, pl. 64.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 133.

Geographical Distribution.—Northern Territory, North Queensland, also New Guinea and Aru Islands.

Nest and Eggs.—Unknown.

Observations.—This beautiful and active little Honey-eater is found in Northern Australia, where it seems to be exclusively confined to the extensive beds of mangroves bordering the inlets of the sea, as we learn from Gilbert.

MYZOMELA NIGRA, Gould.
"Black Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 66.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 138.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 558 (1865). Ramsay, P.L.S.N.S.W., vol. i, 2nd ser., p. 1151 (1886).

Geographical Distribution.—Northern Territory, Queensland (probably), New South Wales, Victoria, South and West Australia.

Nest.—Cup-shaped, oval, shallow; composed of dried grasses, fine shreds of bark, &c.; usually placed in an exposed situation in the forked branches of a bush or tree (Gilbert).

Eggs.—Clutch, 2; roundish or round oval in shape, slightly pointed at one end; texture fine; surface slightly glossy; colour, delicate salmon-pink or flesh tint, blotched and spotted chiefly round the apex with reddish-brown or chestnut and dull or light purple. Dimensions of a clutch in parts of an inch—(1) ·67 × ·54; (2) ·67 × ·53.

Observations.—The range of the splendid little Black Honey-eater extends across the southern part of Australia, Gould having found it on the plains of the Namoi, while Gilbert met the species amongst the Myalls (*Acacia*) in Western Australia.

The interesting species would, however, appear to be more peculiar to inland parts. In October, 1884, I met the Black Honey-eater in the Bull-oak (*Casuarina*) belts of timber that intersect the Mallee country in the Wimmera district, Victoria. The prettily-contrasted black and white plumage of the male agreeably harmonised with the surroundings. The flight of the bird at times is peculiar, being spasmodic rises and falls. On each downward motion a tremulously plaintive note is uttered. I was convinced by the actions of several pairs of birds that they were breeding in the vicinity; but my perseverance, which extended over several days, failed to discover a nest, although good Gilbert told us their nests were usually placed in most conspicuous situations. One he found in Western Australia was in a fork at the

top of a small scrubby bush, not sheltered even by a bough or leaf, while a second one was on the dead branch of a fallen tree, in a similarly exposed situation.

Mr. Chas. French, junr., on learning of my *desideratum*, at once kindly placed a pair of eggs, together with a skin of one of the parents (the male), at my service. All were secured in the Wimmera district, 15th September, 1896.

The late Mr. K. H. Bennett informed Dr. Ramsay that he had found the Black Honey-eater plentiful near Mossgiel, N.S.W., feeding among the Sandal-wood (*Myoporum*) trees. Mr. Bennett succeeded in finding a nest with two eggs, but no data are given.

During the progress of the unfortunate Calvert Exploration Expedition, 1896, it is recorded that on the 2nd October the deceased explorer, Mr. C. F. Wells, shortly before he perished in the "lurid waste-lands, pent in silence, thick with hot and thirsty sighs," found a nest of the Black Honey eater, which flushed from a Ti-tree (Melaleuca) bush as he passed. The nest and its single egg were left at the abandoned depôt in the desert.

Breeding months, September or October to December.

Myzomela pectoralis, Gould.

"Banded Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 65.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 138.

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland.

Nest and Eggs.—Unknown.

Observations.—"The present interesting bird," writes Gould, "was forwarded to me by Bynoe, as having been shot by him on the north coast, but to my regret it was unaccompanied by any information whatever respecting its habits." Nor has any information regarding the species been obtained up to the present time excepting Mr. G. A. Keartland's north-west remarks made during the ill-fated Calvert Exploration Expedition, 1896 7. He says, "At the well near our camp on the telegraph-line near the Fitzroy River these pretty little birds were occasionally seen and specimens obtained. They were also found in considerable numbers at Derby in May, where the blossom afforded them an abundant supply of food. Though the adult males are decidedly black and white, several of those shot appeared to be immature, and had old brown feathers dispersed through the black. I have reason to believe that the young birds of both sexes are plain dark-brown above and pale-brown or dirty-white beneath. What appeared to be adult females corresponded in plumage to the young ones. A deserted nest of this species bore a strong resemblance to that of *M. nigra*, but was lined with a few bits of horse-hair."

Myzomela obscura, Gould.

"Dusky Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 67.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 143.

Previous Descriptions of Eggs.—Le Souëf. Ibis, p. 313 (1896).

Geographical Distribution.—Northern Territory and Queensland, also New Guinea.

Nest.—Cup-shaped, small, frail; composed of fine brownish rootlets; inside lined with long hair. Dimensions over all, $2\frac{3}{4}$ inches by 2 inches in depth; egg cavity, $1\frac{1}{2}$ inches across by $1\frac{1}{2}$ inches deep.

Eggs.—Clutch, 2 usually; oval, compressed at one end; texture fine; surface slightly glossy; colour warm-white, spotted chiefly round the upper quarter with reddish-brown or chestnut and purplish-grey. Dimensions of a clutch in parts of an inch—(1) ·66 x ·5; (2) ·62 x ·5.

Observations.—This obscure-coloured Honey-eater would also appear to be an obscure species. It is confined to Northern Australia. The 13th August, 1885, on Hinchinbrook Island Northern Queensland, I found a nest of this species being built in the mangroves, but, unfortunately, I had to leave that interesting collecting ground before the nest was completed.

Mr. Dudley Le Souëf states a nest of the Dusky Honey-eater was found on 23rd October, 1893, during his visit to Mr. Hislop, Bloomfield River district. The nest was well shaded by foliage near the top of an Ironwood (Eucalypt) tree about 30 feet from the ground. One of the parents was secured.

Another nest containing two eggs was taken by Mr. R. Hislop, 17th October, 1895.

Acanthorhynchus tenuirostris, Latham.

"Spine-bill."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 61.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 149.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 552 (1885). North, Cat. Nests and Eggs, Austn. Mus., p. 220 (1889).

Geographical Distribution.—Queensland, New South Wales, Victoria, South Australia, Tasmania, King Island, and Furneaux Group.

Nest.—Cup-shaped, small, deep; composed outwardly of moss chiefly and bark; inside lined with grass, finished off warmly with feathers; usually placed in a thick bush such as Prickly Acacia or among the close branchlets of a *Banksia*, *Exocarpus*, or near the top of a ti-tree (*Melaleuca*). Dimensions over all $3\frac{1}{2}$ inches by 2 inches in depth; egg cavity $1\frac{3}{4}$ inches across by $1\frac{1}{2}$ inches deep.

Eggs.—Clutch 2–3; somewhat lengthened in form; texture fine; surface slightly glossy; colour pale buff, delicately spotted, especially about the apex, with chestnut and obscure purplish-grey. Dimensions of a clutch in parts of an inch—(1) ·75 x ·57; (2) ·74 x ·55.

A set from Tasmania are larger, rounder, and the markings of a richer brown, the ground colour being also a darker shade on the apex; (1) ·72 x ·53; (2) ·72 x ·53; (3) ·72 x ·52.

Observations.—This ruby-eyed, slender-billed Honey-eater enjoys chiefly a southern habitat. It is an intensely interesting and familiarly known bird in our gardens, where it may often be heard repeating faster and faster its single high-pitched note, and where the bird appreciates the nectar of the Fuchsia bells just as well as the sweets from tubular blooms of Epacris growing in native heath-like tracts.

Not much is known of the breeding economy of the little Spine-bill, consequently their eggs are deemed rare. Except one nest containing young found many years ago at Toorak, near Melbourne, I was unable to observe this Spine-bill's nest in the open till one day (20/11/96), when Mr. G. E. Shepherd, my son, and myself were exploring an enchanting gully near Somerville. Here we discovered in the space of about half a mile three nests—two building, and one with eggs. One nest was prettily ensconced in a bunch of flowering Clematis at the top of a Ti-tree (*Melaleuca*). This nest was subsequently revisited by Mr. Shepherd, who found in it an egg of the Spine-bill, together with the much larger egg of the Pallid Cuckoo (*C. pallidus*). The Spine-bills sometimes build near the flowering Mistletoes (*Loranthus*), upon which they feed.

Ornithologists are divided whether the Tasmanian Spine-bill should be separated from the mainland species or not. However, as Gould pointed out, although very nearly allied, there is a difference in the two birds, the Tasmanian variety being distinguished by its smaller size (which is the reverse of the general rule as regards the insular representatives of the mainland species) and by the much deeper colouring of the crescent-shaped markings on the neck, also of the brown on the abdomen.

The nests found by Gould, both in Tasmania and on the mainland, were built in low shrubs a few feet from the ground, mostly in a species of Leptospermum.

The following is a description of a Tasmanian nest:—Cup-shaped, deep; composed of wool chiefly, grass, and moss; inside lined with feathers. Dimensions over all about 3 inches by $2\frac{1}{4}$ inches in depth; egg cavity 2 inches across by $1\frac{3}{4}$ inches deep. Mr. A. E. Brent has usually found them in a bushy shrub, such as Mimosa "Box" or Wattle-trees. He has also found the unusual complement of four eggs in a Spine-bill's nest. He also recollects taking a Tasmanian Spine-bill's nest with three eggs, and within

three weeks the bird had rebuilt the old nest twice in another position in the same tree, laying each time another set of three eggs. The curious part of the affair was that the succeeding sets were much lighter in colour, the last being almost white, with a few faint spots. Here may be a hint on egg-colouration, in which it appears that in eggs produced frequently and rapidly the colour pales out.

Breeding season, August or September to January; the chief months, both in Tasmania and on the mainland, being October to December.

Acanthorhynchus superciliosus, Gould.

"White-browed Spine-bill."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 62.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 145.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848); also, Hdbk., vol. i, p. 554 (1865).

Geographical Distribution.—South and West Australia.

Nest.—Cup-shaped, neat, compact, round; composed chiefly of rootlets enveloped with strips of bark matted with spider's web; inside lined with the dark red downy substance of Banksia cones or with Zamia wool, fur, &c.; usually placed in a bush or low tree such as a Banksia. Dimensions over all $2\frac{3}{4}$ inches by 2 inches in depth; egg cavity $1\frac{1}{2}$ inches by $1\frac{1}{4}$ inches deep.

Eggs.—Clutch, 1–2; lengthened in form; texture fine; on surface faint trace of gloss; colour pale buff or soft pinkish-white, darker on the apex, finely spotted, more particularly on the apex, with chestnut and dull purplish-brown. Dimensions of single examples in parts of an inch—(1) ·78 x ·52; (2) ·75 x ·53.

Observations.—There is no mistaking the fine, little western Spine-bill, with its white eyebrows. Mr. Wm. White, of South Australia, informs me he has identified this species as far eastward as Kangaroo Island, where he took several nests. Therefore it is on his authority that I have given South Australia as a habitat of the bird.

Gould has described in detail the nest, stating that the eggs are two in number. Possibly that may be the number laid at the height of the breeding season; but at the beginning of the season I found one only. On the 1st October, 1889, at King George's Sound, I discovered two nests of the White-browed Spine-bill building, and watched them carefully. A single egg each was the result. Another nest I found had also a single egg, slightly incubated; while a fourth nest, found on the 7th, contained one young bird. Three nests out of the four were situated on a small prickly-leafed variety of Banksia at a height varying from 5 to 8 feet from the ground.

I often watched the birds with merry chirrup chasing each other round the trees; the noise of their wings as they flew past me made quite an audible sharp "purrt, purrt, purrt" sound.

Breeding months probably include September to December.

MELITHREPTUS LUNULATUS, Shaw.

"White-naped Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 72.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 204.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i., p. 568 (1865). North, Cat. Nests and Eggs Austn. Mus., p. 227 (1889).

Geographical Distribution.—South Queensland, N. S. Wales, Victoria, South Australia, and Kent Group (Bass Straits).

Nest.—Cup-shaped, small, but long or deep; composed of soft shreds of bark, matted outwardly with cotton-like substance, cocoons, portions of moss, grass, &c.; inside lined with mixture of soft vegetable matter such as rootlets, small leaves, &c., in other instances chiefly with soft reddish-coloured bark, and sometimes with fur or hair; usually situated at a good height from the ground, suspended in a swaying branch of a Eucalypt or among the topmost branches of a tall sapling. Dimensions over all 2½ inches by 2-3 inches in depth; egg cavity 1½ inches across by 1½-1¾ inches deep.

Eggs.—Clutch, 2-3; oval, compressed towards one end; texture fine; faint trace of gloss on surface; colour delicate or pale buff, marked chiefly round the apex with reddish-brown or chestnut and dull grey. Dimensions of a clutch in parts of an inch:—(1) ·76 × ·51; (2) ·76 × ·51; (2) ·75 × ·5.

Observations.—This species of Honey-eater is a delightful and familiar little creature, and its plaintive half-whistling, half-hissing note is well known when heard amongst the "forest rafters." It is a pretty sight to see the birds clinging to and feeding amongst a cluster of flowering *Loranthus* (Mistletoe).

The habitat of the Lunulated or White-naped Honey-eater is very extensive, extending from Southern Queensland round to South Australia. It is interesting to note that this Honey-eater was found on Kent Group, Bass Straits, by the expedition of the Field Naturalists' Club of Victoria, November, 1890.

Within its usual boundaries the bird is fairly plentiful. I recollect there was something akin to an irruption of this bird once in the vicinity of Melbourne, notably in gardens at Windsor. It occurred about the season 1866, when I remember particularly the so-called Cape Wattles (but really a south-west Australian variety of Acacia or Albizzia, from whence it was introduced into Victoria by the late Baron von Müller) being crowded with

birds feeding amongst the flowers. As boys, we had no difficulty in "shanghaing" as many as we wanted, and that was so long as the poor birds remained in the trees to be aimed at.

The nest of the Lunulated Honey-eater is not only difficult to get on account of the height at which it is usually built, but because the clever little bird often swings it at the end of a slender bough. However, I once found a beautiful nest suspended almost within reach in the overhanging branch of Black Wattle (*Acacia*).

Mr. C. C. Brittlebank tells me when he wishes to take one of these nests in a difficult position he always selects a windy day for the purpose, then chops the bough containing the nest off. The poor bird remains closely to its charge, supposing, no doubt, that the elements are merely a trifle more boisterous than usual. The coveted prize is safe, and within reach before the dear, deluded bird realises the position of affairs, when it somewhat hurriedly leaves its cosy nest and delicate flesh-tinted eggs to the cause—well, let us say—of science.

Gould found examples of the Lunulated Honey-eater breeding in a state of plumage which he believed to be characteristic of youth. It is just possible that Gould mistook *M. brevirostris* for the young of *M. lunulatus*.

There are eggs of the Lunulated or White-naped Honey-eater in the Dobroyde Collection, taken as early (in a double sense) as June, 1859, and July, 1861, respectively. Mr. Brittlebank has taken them as late as the 14th*, 18th, and 27th January respectively, therefore the extreme limits of the breeding season may be stated as from June to January, the chief months being September to November.

The Pallid Cuckoo is very partial to the nest of this little Honey-eater as a receptacle for its egg.

Melithreptus chloropsis, Gould.

"Western White-naped Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 73.

Reference.—

Previous Descriptions of Eggs.—Gould, Bds. of Australia (1848), also, Hdbk., vol. i, p. 571 (1865).

Geographical Distribution.—West Australia.

Nest.—Usually suspended from small branches near the top of gum-trees (*Eucalypts*), where the foliage is thickest, which renders it difficult to detect. A nest found by Gilbert in October was formed of sheep's wool and small twigs; another found by him in November was attached to a small myrtle-like tree in a thick gum forest, not more than 3 feet from the ground (Gould).

* This nest was lined with white flowers.

Eggs.—Clutch 2–3 ; deep reddish-buff, thinly spotted all over, but particularly at the larger end, with dark reddish-brown, some of the spots being indistinct, while others are very conspicuous. Dimensions 9½ lines (·79 inch) by 6 lines (·5 inch)—(Gould).

Observations.—This western *Melithreptus* is closely allied to *M. lunulatus* ; some authorities say they are identical, but, as Gould points out, it differs from the eastern bird in being larger and having the naked space above the eye greenish-white instead of scarlet.

During my own explorations in western woods I expected to take the eggs. However, I only saw the birds building a nest, which I could not obtain. It was then the beginning of October.

Breeding season, possibly from August to December.

Melithreptus albogularis, Gould.

"White-throated Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 74.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 205.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 572 (1865).

Geographical Distribution.—North-west Australia, Northern Territory and Queensland, also New Guinea.

Nest.—Always suspended to a drooping branch, which swings about with every gust of wind ; is formed of dried, narrow strips of soft bark of the Melaleuca (Gilbert-Gould).

Eggs.—Clutch, 2 usually ; light salmon-colour, blotched and freckled with reddish-brown. Dimensions, 9 lines (·75 inch) x 6 lines (·5 inch), (Gilbert-Gould).

Observations.—The White-throated Honey-eater is the northern representative or sub-species of the Lunulated or White-naped bird coalescing with each other in southern Queensland. Gilbert found the white-throated species abundant in the Port Darwin district. More information would be welcomed respecting its nidification.

I saw what I believed to be fledglings of this species, near Townsville, Q., 16 Sept., 1885.

Melithreptus gularis, Gould.

"Black-chinned Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 71.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 205.

Previous Descriptions of Eggs.—Ramsay, P.Z.S., p. 597 (1875) ; Campbell, Southern Science Record (1883).

Geographical Distribution.—Queensland, New South Wales, Victoria, South and West Australia.

Nest.—Cup-shaped; composed of fine grasses and bark webbed together with spiders' nests (Ramsay); usually suspended in the forked twigs of a leafy tree.

Eggs.—Clutch, 2–3; inclined to oval, but more compressed at one end; texture, fine; faint trace of gloss on surface; colour, delicate or pale buff, moderately spotted with chestnut and dull purplish-brown, the markings being chiefly on the apex. Dimensions of a clutch in parts of an inch (1) ·78 x ·57; (2) ·75 x ·55.

Observations.—The Black-chinned Honey-eater is one of the larger species of its genus, approaching next in size to the Strong-billed Honey-eater of Tasmania. It ranges chiefly over the southern half of Australia; but is not usually found in the vicinity of the coast or in thick forest.

I never recollect identifying this bird in the open; but have had skins kindly forwarded for my examination from Mr. Wm. White, of South Australia, and more recently (1896) from Mr. H. E. Hill, who collected the bird in the Bendigo district, Victoria. Eggs, however, I received from Mr. H. O. Lang, Dubbo district, New South Wales. The specimens are somewhat smaller than I expected to see; but I find Dr. Ramsay gives even smaller dimensions (·73 x ·55 inches) than those of the specimens I have described. Gould has only described the nest and eggs by analogy.

Melithreptus validirostris, Gould.

"Strong-billed Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 70.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 206.

Previous Descriptions of Eggs.—Gould, Bds. of Aust. (1848); also Hdbk., vol. I, p. 565 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 225 (1889).

Geographical Distribution.—Tasmania and King Island.

Nest.—Cup-shaped, deep, round; composed chiefly of wool and grasses, in some instances of stringy-bark; inside lined with a few flowering portions of grass, &c.; usually suspended in the topmost branches of a sapling or other tree.

Eggs.—Clutch, 3 usually; nearly oval, slightly compressed towards one end; texture, fine; surface, without gloss; colour, beautiful flesh tint, moderately but boldly blotched and spotted, and chiefly about the apex, with rich, reddish-brown or chestnut and dull purple brown. Dimensions of a pair in parts of an inch (1) ·88 x ·66; (2) ·86 x ·63.

Observations.—This fine Honey-eater—the largest of a most interesting genus—is peculiar to Tasmania and King Island, where

I have myself procured the bird. Gould was indebted to the late Rev. Thomas J. Ewing, D.D., for the nest and eggs of the Strong-billed Honey-eater, which he (Gould) failed to find himself during his sojourn in Tasmania.

I have to thank the Rev. T. H. Hull, of Tasmania, for the first examples of eggs in my collection, which were obtained during the season 1874.

Breeding season, August to December.

MELITHREPTUS LÆTIOR, Gould.

"Golden-backed Honey-eater."

Figures.—Gould–Sharpe, Bds. of New Guinea, vol. iii, pl. 40.

Reference.—

Geographical Distribution.—North-west Australia, Northern Territory, Queensland (interior probably), and South Australia.

Nest and Eggs.—Unknown.

Observations.—As Gould states, although very closely allied to *M. gularis*, this species is altogether a much more finely-coloured bird. In size it is slightly larger, and it is at once to be distinguished by its white under surface, and the beautiful lemon-yellow on the back of the neck, as well as by the *bright yellow* naked skin surrounding the eye, which part is of a *beautiful bluish-green* in *M. gularis.*

Dr. Sharpe, in referring to Gould's type of the beautiful and well-named Golden-backed Honey-eater, is of opinion that it "is apparently a very old male in full breeding plumage" of *M. gularis.* Many answering to Gould's type (*M. lætior*) have since been found. The talented doctor must also be prepared to accept a female as an "old male," since Mr. G. A. Keartland was good enough to present me with one which he shot in the far north-west. Mr. Keartland informs me he found the beautiful Golden backed Honey-eater plentiful on the Fitzroy River from Mount Campbell to Derby. In May these birds had apparently paired.

News of the nidification of this species is awaited with interest.

MELITHREPTUS BREVIROSTRIS, Vigors and Horsfield.

"Brown-headed Honey-eater."

Figure.—

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 207.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883). North, Cat. Nests and Eggs, Austn. Mus., p. 225 (1889).

Geographical Distribution.—Queensland, New South Wales, Victoria, South and West Australia.

Nest.—Cup-shaped, small, neat, composed of grasses or fine shreds of bark matted together with portions of spiders' cocoons greenish and white; inside lined warmly with a ply of fur or hair; usually suspended at the extremity of a Eucalypt branch in open forest. Dimensions over all $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. in depth; egg cavity, $1\frac{3}{4}$ in. across by $1\frac{3}{4}$ in. deep.

Eggs.—Clutch, 2–3; inclined to roundish-oval in shape, texture fine; faint trace of gloss on surface; colour, reddish-buff or flesh-colour, darker on the apex, which is sparingly spotted and splashed with reddish-chestnut, a few specks also appearing here and there over the shell; other specimens are sparingly speckled all over. Dimensions of a clutch in parts of an inch (1) ·77 x ·57; (2) ·76 x ·56; (3) ·74 x ·57. An odd example, ·72 x ·58.

Observations.—Gould was in doubt about the existence of this species; possibly he mistook it for the youthful *M. lunulatus.* I fear he was erroneously informed when he states the characteristic bare space above the eyes of *M. brevirostris* is *greenish-blue.* From specimens I have examined immediately after being shot it should be a *delicate flesh tint.* The bird is otherwise plainly coloured, is terribly active, and possesses a disagreeable, rough, rattle-like note.

While on a collecting trip at Bagshot, Bendigo district, October, 1880, I procured examples of bird, nest and egg. Dr. Ramsay kindly identified the bird for me, which enabled me to describe the nest and egg. I have since observed the bird in various parts of Victoria, my last recollection of them being on the 25th September, 1897, when I saw a flock of six or seven merry birds feeding on the pollen, &c., of the flowering cones of a stunted Banksia that grew on the plains near Mount Cotteril. I was agreeably surprised to notice the Brown-headed Honey-eater in Western Australia; therefore its habitat extends across the southern half of the continent.

On the Bagshot trip already referred to I was accompanied by Mr. James Peatling, a local farmer. We found Brown-headed Honey-eaters somewhat numerous, and I succeeded in obtaining a nest, which was suspended to the extremity of a swaying branch of a Box-tree (*Eucalyptus viminalis*). This nest was composed of grass, thickly woven in and out with wool and fur. The latter material the birds pull off live animals. We were attracted by the lively actions of this curious little Honey-eater upon the back of a native bear (*Koala*), which had taken up its usual position in the fork of a tolerably tall gum. The bird was clinging on in a very comical manner, while busily engaged plucking off a mouthful of fur. One of our party, also desiring to rob the animal of its furry coat—and of its life—fired, hit the bear, but did not dislodge it. The discharge, however, merely frightened our little

feathered friend on to a neighbouring branch, and before the gun was reloaded the bird had commenced operations again on the back of the bear.

Mr. A. J. North informs us there is in the Dobroyde collection the nest and eggs of this species, together with the birds shot therefrom, obtained by Mr. J. Ramsay at Cardington, on the Bell River, November, 1867. These interesting specimens were, however, kept dark, and were not described till the "Catalogue of Nests and Eggs" appeared, 1889.

November, 1895, Mr. C. C. Brittlebank found a pair of Brown-headed Honey-eaters building in the bed of the Myrniong Creek below his house. The birds first attracted his attention by pulling hair off the cattle. The same season Mr. G. E. Shepherd found two pretty nests near his nurseries, Somerville, the second nest being taken on the 3rd January. The following season he found other two nests, but they each only contained an egg of the Pallid Cuckoo.

Breeding months, September to January.

Melithreptus melanocephalus, Gould.

"Black-headed Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 75.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 207.

Previous Descriptions of Eggs.—Swan, Proc. Roy. Soc., Tasmania (1885). Campbell, Victorian Naturalist (1886). North, Cat. Nests and Eggs, Austn. Mus., app. (1890).

Geographical Distribution.—Tasmania, King Island, and Furneaux Group.

Nest.—Cup-shaped, somewhat deep and pointed at the base, with thick bulging sides, composed of wool chiefly, moss, and spiders' cocoons, with a few threads of stringy-bark round the rim ; inside warmly lined with fur and feathers ; usually suspended in the tender foliage at the extremity of a pendulous branch in a stringy-bark (Eucalypt) sapling or tree, where it is difficult to detect. Dimensions over all 3 inches by 4 inches in depth ; egg cavity $1\frac{3}{4}$ inches across by $1\frac{3}{4}$ inches deep.

Eggs.—Clutch, 3 usually ; oval compressed towards one end ; texture fine ; surface, slightly glossy ; colour, delicate flesh tint, marked moderately, and chiefly about the apex, with well defined spots of rich reddish-brown, or chestnut and purplish-brown. Resemble those of *M. validirostris*, but are proportionately smaller. Dimensions of a clutch in parts of an inch (1) ·78 x ·57 ; (2) ·78 x ·57 ; (3) ·76 x ·56.

Observations.—This interesting Honey-eater, with its head entirely black, is peculiar to Tasmania and King Island, where specimens were procured by the expedition of the Field Naturalists'

Club of Victoria, 1887. It may possibly be found on the Furneaux Group, although we did not notice it there during a subsequent trip, being engaged chiefly amongst the sea-birds.

During my Tasmanian excursion (1883) I was much delighted at the lively prying actions while searching for food of both the Strong-billed and Black-headed Honey-eaters; the latter also possesses quite a cheerful little song. I endeavoured persistently to discover their nests, but only found fully-fledged young of the Strong-bill, which species had evidently commenced breeding about the end of August or the beginning of September.

Much interest was attached to the Black-headed Honey-eater, because its nest remained so long undiscovered, and the finding of the nest completed those of the Honey-eaters of Tasmania.

At the meeting of the Royal Society of Tasmania (November, 1884), Mr. E. D. Swan drew attention to the extremely rare nest and eggs, in fact, the first ever taken, of the Black-cap (*M. melanocephalus*), which had been found during that month at Austin's Ferry, Bridgewater, and presented to the Museum by Miss A. Brent, Rosemeath.

It is always a pleasure for me to write up an account of the first find of any nest and eggs new to scientific knowledge. It is more so in this instance, because the finders were lady field naturalists. Here is the authenticated story of the discovery by the Misses Brent of the nest of the Black-capped Honey-eater, as told by their brother (Mr. A. E. Brent) :—

"The first intimation I received of a nest of our interesting little Black-capped Honey-eater was from my two youngest sisters. One day they chanced to witness one of these birds picking wool from a sheep and flying with it to the top of a small-leafed gum sapling. From the first they could see that it would be impossible to reach the spot, therefore they decided to remain watching for sometime. Then armed with a pair of field-glasses they watched the progress of the nest from day to day until they made certain that the bird had commenced sitting. Armed again (but this time with an axe) my sisters set forth to fell the tree—trusting to chance, as they said afterwards, that the nest and perhaps the contents might be saved in the fall.

"The tree fell midst briars and scrub, and after much scrambling and searching they at last discovered the nest with the poor little bird clinging fast to it although the nest was almost upside down. Seeing this they rushed forward, and in so doing scared the bird away, but owing to the thick mass of leaves, &c., crushed under the nest, the eggs were saved from being broken. Full of excitement the girls related the story to me, and after this a diligent search was made for more with the result that several nests were taken during that season (1884)."

As Mr. C. C. Brittlebank discovered in the case of the Lunulated or White-naped Honey-eater on the mainland so it has been independently proved in Tasmania that the Black-capped Honey-eater will cling to its nest, more especially during windy weather, if the tree containing it be felled.

Mr. Brent proceeds to state, "A friend and I discovered one which was impossible to obtain by climbing at the extreme end of a horizontal branch of a large White-gum (*Eucalypt*). Our only way was to fell the tree or sling the branch with a rope. The latter course was decided upon. A noose was made round the limb and pushed with a stick as far out as possible, then the rope was passed over another branch higher up and the other end made fast at the ground. With a light saw the branch was severed. I thought to retain my hold at the butt end, but, alas, the bough proved too much for me, it tipped and swung down, the little bird remaining fast to the nest which was by this time completely upside down. We could not venture too near for fear of disturbing her, so I crept in under cover of the foliage and cut the branch again turning it upright, and in this way we took a full set of three eggs and an egg of the Pallid Cuckoo.

"Since discovering this little fact, I have taken many nests of the Black-capped Honey-eater by felling the trees, but I must say not always successfully. My experience has taught me to choose a boisterous day ; even a good, steady breeze will suffice, for nature prompts the sitting bird to cling more closely to her nest. Care should be taken that the falling tree does not strike or foul another tree."

A nest, with eggs, kindly forwarded to me for description, by Mr. Brent, was taken in like manner, and when the poor bird was rescued from the fallen foliage, she was covering her own eggs, beside an additional burden—an egg of the Pallid Cuckoo. Date, 21-11-96.

Mr. Brent has also taken the egg of the Fan-tailed Cuckoo (*C. flabelliformis*) from the nest of the little Black-cap, it being a most unusual occurrence to find that cuckoo's egg in an open nest.

In the Appendix of the "Catalogue" of the Australian Museum it is stated that Dr. Holden, of Circular Head, Tasmania, found several nests of the Black-capped Honey-eater in December (1889). One in particular was commenced on the 7th of that month, contained three fresh eggs by the 25th. One nest had no wool, but was chiefly composed of green moss and spider's web, with a lining of flower-seeds.

The male Black-capped Honey-eater, and doubtless many other kinds of birds, sometimes feed the female upon her nest, especially if the weather be windy.

Breeding months from October to December.

PLECTORHYNCHUS LANCEOLATUS, Gould.

"Striped Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 47.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 208.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 526 (1865). North, Cat. Nests and Eggs Austn. Mus., p. 209 (1889).

Geographical Distribution.—Queensland, New South Wales, Victoria, and South Australia.

Nest.—Cup-shaped, deep; composed of fibrous roots and grasses, interwoven with wool or cotton-like texture of flowers and feathers; inside lined sparingly with grass and hair; usually suspended at the extremity of a branch of Casuarina, Myall (*Acacia*), or other tree in open timbered tracts of the interior. Dimensions of a nest given in the Australian Museum Catalogue are—interior 3 inches across by 4 inches deep.

Eggs.—Clutch, 3–4, occasionally 5; lengthened in form, somewhat pointed towards one end; texture fine; surface slightly glossy; colour, warm white minutely spotted with reddish-brown or chestnut and purplish-grey, the markings being more numerous about the upper quarter. Dimensions of a pair in parts of an inch (1) ·98 x ·68; (2) ·98 x ·67. Of a larger-sized set—(1) 1·04 x ·69; (2) 1·04 x ·68; (3) 1·03 x ·69.

Observations.—This unique and interesting form of Honey-eater is strictly a denizen of the interior provinces from Queensland to South Australia where it loves the pine ridges, and open tracts of Casuarina, Acacia, &c. The bird is the possessor of a loud whistling note, and is usually found in pairs.

On one occasion only did Gould discover the nest, which was suspended from the extreme tip of a Casuarina branch overhanging a stream.

In 1880 I received from Mr. R. Macfarlane, then at Mallee Cliffs Station (N.S.W.), a full set of four eggs of the Striped Honey-eater. September the following year Mr. A. J. North reports he received from the Wimmera district, Victoria, a beautiful nest together with a set of eggs, while it is stated the late Mr. K. H. Bennett found this Honey-eater breeding plentifully in the neighbourhood of Ivanhoe and Mossgiel in the interior of New South Wales.

On the 9th October, 1893, Mr. C. Barnard found in Queensland a nest of the Striped Honey-eater with the unusually full complement of five eggs.

Mr. J. W. Mellor, (South Australia), writes me that he took about the end of September, 1894, near Lakes Alexandrina and Albert, a nest of this species containing four eggs. Both parents were secured for Museum purposes.

I have a note from an interior friend of an attractive nest of the Striped Honey-eater he saw. It was suspended to the pendulous branches of a Myall (*Acacia*), and decorated with long Emu feathers loosely stuck on which were flying in the breeze.

Gould incidentally states that the circumstances of his having seen fully-fledged young and eggs at the same time prove that these birds rear at least two broods in the season.

Breeding months, September to December or January.

GLYCYPHILA FULVIFRONS, Lewin.

"Tawny-crowned Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 28.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 210.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848) also Hdbk., vol. i, p. 496 (1865). North, Cat. Nests and Eggs Austn. Mus. (1889).

Geographical Distribution.—South Queensland, New South Wales, Victoria, South and West Australia, Tasmania, and Kent Group; and probably other islands in Bass Straits.

Nest.—Cup-shaped, deep; composed of flat, dead rushes or broad grass, sometimes with strips of bark and a few spiders' cocoons added; lined inside with grass, finally with feathers and a downy vegetable substance. In Western Australia the lining is chiefly composed of an elastic ply of Zamia (Cycad) wool; usually placed close to the ground in the heart of a low bush in open heath-like country. Average dimensions over all $4\frac{1}{2}$ inches by $2\frac{3}{4}$ inches in depth; egg cavity $2\frac{1}{4}$ inches across by $1\frac{5}{8}$ inches deep.

Eggs.—Clutch, 2 usually; inclined to be lengthened in form and large compared with the size of the parent; texture of shell very fine; surface without gloss; colour, white, very sparingly and lightly spotted with chestnut, the markings appearing more particularly about the apex. Dimensions of a clutch in parts of an inch—(1) ·88 x ·63 (2) ·87 x ·63.

Observations.—This active Honey-eater has a habitat extending across the southern portion of Australia, including Tasmania and some of the islands in Bass Straits. The bird shows a preference for open, heathy, or low scrubby localities, and is remarkably shy.

Of all the Honey-eaters, I think this bird has the most rapid flight. It frequently mounts high into the air, hence the trivial name of "Sky-lark" applied to the bird by youths in the neighbourhood of Albany (W.A.).

Besides eating insects, it is commonly known in the King George's Sound district that this Honey-eater regales itself on the nectar of the flaming Bottle-brush (*Callistemon*) to such an extent that at certain seasons the bird becomes intoxicated and is easily

caught beneath the bushes, helpless. The same sometimes applies to the Long-billed Honey-eater or "Yellow-wing" as it is locally called.

History repeats itself. Gould recorded regarding this Honey-eater: "The site generally chosen for its nest, as observed at the Swan River, is a low bush or scrubby plant, in which it is often placed near the ground." I had frequently observed this bird in Victoria, and on the adjacent islands in Bass Straits without finding its nest, but it was just forty-one years after Gould wrote his remarks, I was strolling over the limestone ridges of the Lower Swan, when I flushed a Tawny-crowned Honey-eater and found my first nest of this wild species in such a position as is exactly described by Gould (*i.e.*, Gilbert). The nest contained two eggs, partly incubated. Date, 19th November, 1889.

The month previous, when in the Tor Bay district, near Albany, shepherd brought me a nest, also with two eggs.

Early in the season of 1896, on the heathy grounds near Cheltenham, Vic., a pair of Tawny-crowned Honey-eaters was observed uttering distressing cries over their nest in a bush about 15 inches from the ground. The cause of the disturbance was a snake, which had extracted one of the young from the nest and was about to swallow it. The youthful collectors who were attracted to the spot by the birds' calls had nothing to battle the snake with except the handle of a butterfly net. With this they struck the reptile, which quickly made its escape.

In a communication to me Mr. G. K. Hinsby writes:—"*Re Glycyphila fulvifrons*, I note that Gould mentions it as only inhabiting the northern parts of Tasmania. I obtained birds and eggs on the extreme south end of Bruin Island, near Cloudy Bay Lagoon (Dec., 1884). The nest was cup-shaped, made of She-oak (*Casuarina*) needles, lined with wool and cow's hair. I never saw a nest look so strange, not a foot from the ground, in one of the stunted Bottle-brush shrubs. I saw the male bird perched on a dead branch of a small gum-tree pouring forth its peculiar note. As I approached it flew, but I stopped it before it had gone far, and the shot flushed the female from her nest close by, which I found without difficulty. The eggs (two) were slightly incubated and were almost white, with a faint pinkish shade, and spotted with a few purplish-black spots."

Breeding months, August to December or January.

GLYCYPHILA ALBIFRONS, Gould.

"White-fronted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 29.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 211.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 498 (1865); North, Cat. Nests and Eggs, Austn. Mus., p. 197 (1889).

Geographical Distribution.—New South Wales, Victoria, South and West Australia.

Nest.—Very flat structure, the base being composed of very thin dried stems of a climbing plant and grasses, matted together with a little wool, over which is placed a layer of wool intermingled with a few blades of grass. Diameter of base, 4 inches; the layer of wool $2\frac{3}{4}$ inches, and the whole structure $1\frac{1}{2}$ inches in thickness. There is just sufficient depression in the centre to keep the eggs in position (North).

Eggs.—Clutch, 2; of a light saturnine-red ground-colour; on the larger end they are thickly spotted, and in a few places blotched with irregular-shaped markings of reddish-chestnut and chestnut-brown, but over the remainder of the surface the markings are much smaller and more sparingly distributed; on the larger end are obsolete spots of purplish-grey. Dimensions (A), ·78 x ·57 inch; (B), ·82 x ·58 (North).

Observations.—Gould first observed this fine species in the great Murray Scrub of South Australia, where he succeeded in killing several specimens of both sexes. It is also an inhabitant of the inland districts of Western Australia, and likewise found in the interior of Victoria, notably the Wimmera district, and of New South Wales, where it is a scarce species. I believe it was seen in the North-west Desert by the Calvert Expedition, 1896.

I have given the detailed description of the nest as given in the "Catalogue" of the Australian Museum, taken by the late Mr. K. H. Bennett at Ivanhoe, New South Wales, October, 1886. Gould just mentions in general terms that the nest is "very similar to that of *Meliornis longirostris*, but more shallow and less neatly formed, and that some of the nests observed were constructed in the fork of a small dead branch in an exposed situation."

Breeding months, August to February (Gould).

GLYCYPHILA FASCIATA, Gould.

"White-breasted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 30.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 212.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1885). North, Cat. Nests and Eggs, Austn. Mus. app. (1890).

Geographical Distribution.—Northern Territory and Queensland.

Nest.—Unusual shape for that of a Honey-eater being domed with a side entrance; composed entirely of paper-like Melaleuca bark; lined inside with the same but finer material; usually suspended from a Melaleuca tree overhanging water.

Eggs.—Clutch, 3; elongated in form; texture of shell very fine; surface without gloss; colour, white, numerously freckled and spotted like Wrens' (*Maluri*) eggs, with reddish-brown, more particularly about the apex. Dimensions in parts of an inch, of a clutch (1) ·82 x ·54; (2) ·8 x ·52.

Observations.—This white-breasted *Glycyphila* enjoys a habitat across Northern Australia. In May, 1884, I was indebted to the late Mr. George Barnard, of Coomooboolaroo (Q.), for the eggs of this interesting species. His son, Mr. H. Greensill Barnard, subsequently wrote me:—"*Re Glycyphila fasciata*, the breeding months are October and November. In November, 1893, I found five nests on the Dawson River, three of which were ready for eggs, one containing a set of three eggs, and the fifth had three newly-hatched young. The nests are always built on long, drooping twigs overhanging water, and at times are very difficult to reach. The trees generally selected are Melaleucas, the nests being built of the bark of that tree."

GLYCYPHILA OCULARIS, Gould.

"Brown Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 31.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 213.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 501 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 198 (1889).

Geographical Distribution.—Northern Territory, Queensland, New South Wales, West and North-west Australia.

Nest.—Cup-shaped, small; delicately constructed of soft bark (notably Melaleuca) with a few spiders' cocoons added, and finished round the rim with spiders' web; in Queensland lined inside with the shiny substance composing cocoons of a mantis; in Western Australia cosily lined with the light brownish downy substance gathered from the stems of *Zamias (Cycads)*; usually placed within reach, suspended among the upright twigs of a bush or a small tree. Dimensions over all, $2\frac{1}{2}$ inches by $1\frac{1}{2}$–$2\frac{1}{2}$ inches in depth; egg cavity, $1\frac{1}{2}$ inches across by $1\frac{1}{8}$–$1\frac{1}{2}$ inches deep.

Eggs.—Clutch, 2; short, peculiarly compressed about one quarter, making the smaller end appear somewhat blunt; colour, sometimes uniformly white, but usually marked with a very few spots of pale chestnut or light reddish-brown, especially about the apex. Dimensions of a clutch in parts of an inch: (1) ·67 x ·51; (2) ·66 x ·51.

Observations.—Excepting the extreme south-eastern portion of the continent, this cheerful little honey-eater enjoys a habitat on either side of Australia.

At Townsville, 1885, this bird first attracted my attention by its merry, Reed-warbler-like song, which is exceedingly cheerful. Gould describes it as "remarkably shrill, rich, clear and distinct in tone." He also remarked that when the female is sitting upon her eggs the male sings all day long, with scarcely any intermission.

On the Fitzroy River, near Rockhampton, the bird was so numerous that I had no difficulty in one day (2nd October) in discovering three of its small nests which were suspended in thick Melaleuca bushes, each containing a pair of eggs. One set, however, was nearly hatched. Subsequently, more inland of Coomooboolaroo, I found the merry little Honey-eater quite at home among the orange trees standing in the garden, lining its nest with the soft substance gathered off the bursting vine buds, &c. I should have remarked that those nests found on the Fitzroy were furnished with the glazed, soft substance of mantis cocoons.

Still more delighted was I a few seasons afterwards to find this species on the opposite side of the continent, and to hear the familiar merry songs along the shores of the Swan waters. There I also found a pair busily building a nest suspended to the dead, drooping twigs of an Acacia, the nest in this instance being lined with the woolly substance gathered from numerous Zamia palms or Cycads.

Before I left the locality (23rd November, 1889) I took a pair of eggs which were of the characteristic light colour of those of the eastern birds, and resembling those found in the days of yore by good Gilbert.

In one instance in Western Australia Gilbert found a nest attached to the slender fibrous roots hanging beneath a bank over a pool of water—surely a very unusual situation.

Breeding months, September to December.

GLYCPHILA SUBOCULARIS, Gould.

"Least Honey-eater."

Figure.—

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 214.

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland.

Nest and Eggs.—Unknown.

Observations.—With regard to the least Honey-eater of the northern coast, Gould appeared doubtful whether it was really a good species. First he united it with *G. ocularis*, then upon further examination separated it again, remarking that the *G. subocularis* is a smaller bird than *G. ocularis*, and consequently one of the most diminutive (only $4\frac{3}{4}$ inches long) of the Meliphagous birds.

GLYCYPHILA MODESTA, Gray.

"Brown-backed Honey-eater."

Figure.—Gould-Sharpe, Bds. of New Guinea, vol. iii, pl. 46.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 215.

Previous Descriptions of Eggs.—Ramsay, P.Z.S., p. 385 (1868). Campbell, Victorian Naturalist (1887). North, Cat. Nests and Eggs, Austn. Mus. app. (1890).

Geographical Distribution.—North Queensland, also New Guinea and Aru Islands.

Nest.—Bulky, somewhat long in shape, domed with a hooded side entrance; composed of strips, narrow and broad, of the paper-like Melaleuca bark, matted together; lined inside with softer bark of the same kind; usually suspended on a Melaleuca, particularly from a branch overhanging water. Length 7½ inches, diameter 3½ inches; entrance, which is about the centre of the structure, 1 inch across.

Eggs.—Clutch 2, rarely 3; long oval, compressed towards one end; texture of shell very fine; surface without gloss; colour, pure white, with here and there very minute dark brown, almost black, specks or dots. Dimensions in parts of an inch:—(1) ·76 x ·51; (2) ·75 x ·5.

Observations.—The habitat of the Brown-backed or Dusky honey-eater is Northern Queensland, with an extension on the opposite coast of New Guinea, dwelling about Melaleuca swamps.

During our Cardwell camp I found a pair of these birds commencing to build (7 September, 1885), their dome-shaped nest in their favourite tree overhanging a stream.

With regard to the dome-shaped structure of the nest, it is worthy of remark that while the two southern species—*G. fulvifrons* and *G. albifrons*—build cup-shaped or open nests, the two northern kinds—*G. fasciata* and *G. modesta*—build covered-in structures. This would lead us to suppose, from an oological point of view, there was some specific or sub-specific difference between the two sets of birds. But, possibly, the northern birds have been led to conceal their eggs, as well as to suspend the nest over water where it is difficult to reach, to escape some natural enemy.

Mr. J. A. Boyd sent several sets of eggs of the Dusky Honey-eater to the Australian Museum from the Herbert River, possibly that bird's southern limit.

Further north on the Bloomfield River, Mr. Dudley Le Souëf found several of the dome-shaped nests, suspended generally at a height of about 8 feet from the ground in Melaleuca saplings.

The following is one of Mr. W. B. Barnard's notes on the same species:—"I am sending you a skin of this little Honey-eater, or Weaver-bird, which builds a hanging nest composed of Ti-tree (Melaleuca) bark, with entrance at the side; length about 6 inches;

lays two long eggs, white, with minute black spots. Builds in the forest country in November and December, usually in little trees about 10 feet high."

Breeding months, end of August to February.

Glycyphila albiauricularis, Ramsay.

"Broadbent Honey-eater."

Figure.—Gould-Sharpe, Bds. of New Guinea, vol. iii, pl. 45.

Reference.—Cat. Bds. Brit. Mus. vol. ix, p. 217.

Geographical Distribution.—North Queensland and New Guinea.

Nest and Eggs.—Unknown.

Observation.—The discovery of this little Honey-eater is due to the energies of that persevering field-collector, Mr. Kendal Broadbent, who first found it in south-eastern New Guinea. In the great folio work of the birds of that country Dr. Sharpe clearly contrasts the species with its close allies.

Entomophila picta, Gould.

"Painted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv., pl. 50.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 219.

Geographical Distribution.—New South Wales, Victoria, and South Australia.

Nest.—The frailest structure possible, most ingeniously suspended by the rim to the twigs and thick drooping leaves of the *Acacia pendula*, and entirely composed of very fine fibrous roots (Gould).

Eggs.—Unknown.

Observations.—Gould states that this beautiful little Honey-eater is an inhabitant of the interior of New South Wales, where he found it frequenting the Myalls (*Acacia*) and other trees bordering the extensive plains.

It is an interesting fact that this interior bird should have been taken in the wooded wilds of the Upper Yarra track. Specimens are in the National Museum, Melbourne, labelled from that locality.

Gould observed that this rare little creature is very active among the branches, capturing insects on the wing and darting forth and returning to the same spot, much after the manner of Flycatchers. During flight it repeatedly spreads its tail, when the white portion of the feathers shows very conspicuously, while the yellow colouring of the wings also contributes to the beauty of its appearance. Its song is loud and not very harmonious.

The eggs are still a desideratum. The only nest on record was found by Gould on the 5th September, 184–, and contained two nearly fledged young.

Entomophila rufigularis, Gould.

"Red-throated Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv., pl. 52.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 219.

Previous Description of Eggs.—Ramsay, P.L.S.N.S.W., vol. ii, p. 111 (1878); Keartland, Victorian Naturalist (1897).

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland.

Nest.—Cup-shaped, neat, and somewhat deep; composed of fine grasses matted outside with spider's white web; inside lined with grasses only; usually suspended by one side of the rim to a slender twig of a low (Bauhinia) tree, but occasionally high in a Eucalypt; dimensions over all, about 2 inches by 3½ inches in depth.

Eggs.—Clutch, 2-3; inclined to oval; texture, fine; surface glossy, or slightly so. These eggs vary much, the general type resembling in character those of *Maluri* or *Acanthizæ*, being warm white, spotted and blotched, particularly round the apex, with reddish-brown or chestnut and purplish-brown. Dimensions of two clutches:—A (1) ·71 × ·51; (2) ·7 × ·5; (3) ·68 × ·52; B (1) ·72 × ·49; (2) ·71 × ·5; (3) ·67 × ·45.

Another type resembles those of *Ephthianura albifrons*, being white, sparingly spotted with purplish-brown from dark to light shades. Dimensions:—(1) ·73 × ·52; (2) ·72 × · 53; (3) ·72 × ·51.

A third type resembles those of *Glycyphila modesta*, but is smaller, being white, minutely marked with dark spots.

Observations.—Like the Rufous-breasted (*E. albigularis*), the Red-throated Honey-eater is distributed over Northern Australia. Dr. Ramsay states it has been found breeding in the neighbourhood of Georgetown, in the Gulf of Carpentaria country, during the months from September to March. His examples of nest and eggs were sent to him by Mr. Armit, and were taken in an *Erythrina* tree.

I had the privilege of critically examining several sets of eggs of the little Red-throated Honey-eater, taken by Mr. G. A. Keartland in north-western Australia, where the birds appeared to be numerous, for he informs me he obtained no less than thirty nests between the 20th February and 16th March, 1897, chiefly in the Fitzroy River district. Mr. Keartland also tells me that the nests were usually situated low in a *Bauhinia* tree, but sometimes were placed high in a Eucalypt. The various types of eggs above described are in Mr. Keartland's collection.

Mr. Keartland says, at nesting time, which is immediately after the tropical rains of January and February, the Red-throated honey-eaters become very tame. On several occasions he has stood under a tree within 5 feet of where the birds were building their nest.

ENTOMOPHILA ALBIGULARIS, Gould.

"Rufous-breasted Honey-eater"

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 51.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 219.

Previous Descriptions of Eggs.—Gould, Bds. of Australia (1848); also, Hdbk, vol. i, p. 532 (1865).

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland; also, New Guinea and Aru Islands.

Nest.—Cup-shaped, small, deep; composed of narrow strips of soft paper-like bark of the Melaleuca, matted together with small vegetable fibres, and slightly lined with soft grass; suspended from the extremity of a weak projecting branch overhanging water (Gilbert).

Eggs.—Clutch, 2–3; rather lengthened in form, and not unlike those of *Malurus cyaneus* in the colour and disposition of their markings, their ground colour being white, thinly freckled all over with bright chestnut-red, particularly at the larger end. Dimensions, 9 lines (·75 inch) x 6 lines (·5 inch)—(Gilbert).

Observations.—All the knowledge we possess at present of the small Rufous-breasted (White-throated of Gould) Honey-eater is limited to good Gilbert's researches in Northern Australia. He says: "I first met with it on Mayday Island, in Van Dieman's Gulf, where it appeared to be tolerably abundant. I afterwards found it to be equally numerous in a large inland mangrove swamp near Point Smith. I never observed it anywhere than swampy situations, or among mangroves bordering deep bays and creeks of the harbours. Its small pensile nest is suspended from the extremity of a weak projecting branch in such a manner that it hangs over the water, the bird always selecting a branch bearing a sufficient number of leaves to protect the entrance from the rays of the sun. I found a nest in the latter part of November, and another in the early part of December, which contained three eggs each, while a third procured towards the end of January had only two. During the breeding season it exhibits considerable pugnacity of disposition, and instead of its usual pretty note, utters a chattering and vociferous squeaking."

ENTOMOPHILA LEUCOMELAS, Cuvier.

"Pied Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 49.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 220.

Previous Description of Eggs.—Keartland, Victorian Naturalist (1897).

Geographical Distribution.—New South Wales, Victoria, South, West, and North-west Australia.

Nest.—Cup-shaped, somewhat shallow; composed of pieces of grass (Spinifex) matted well with spiders' web; inside lined with finer grass; usually suspended by the rim in the horizontal forked branchlet of a low tree. Dimensions, over all, about 4 inches; egg cavity about 2 inches across (Keartland).

Eggs.—Clutch, 2–3; oval in shape, more compressed at one end; texture, fine; surface slightly glossy; colour, soft, warm, white or light yellowish-white, finely but strongly spotted all over with sepia or dark umber, intermingled with spots and patches of light or dull grey. Quite exceptional in colour and character to the general rule for Honey-eaters' eggs, and resemble more small eggs of the common Wood-swallow (*A. sordidus*). Dimensions of a clutch in parts of an inch (1) ·92 x ·65; (2) ·9 x ·65; (3) ·89 x ·65. A smaller pair (1) ·86 x ·62; (2) ·86 x ·61.

Observations.—The Pied Honey-eater ranges across Southern Australia. Gilbert says it is a periodical visitor to the west, where it arrives in the latter part of October. He has observed the birds assembling in great flocks, which continue to soar during the greater portion of the day—a rather remarkable trait for Honey-eaters.

However, in the North-west Desert, Mr. G. A. Keartland notices something similar, for he records, "Towards the end of October (1896) flocks of these birds frequently passed us going north."

The knowledge we possess about the rare Pied Honey-eater is somewhat scant. The nest and eggs collected by the late Mr. K. H. Bennett, and described by Dr. Ramsay* were no doubt, as Mr. Keartland has pointed out, referable to the Pied Robin (*P. bicolor*), and not the Pied-Honey-eater.

I had the eggs (two clutches) in my collection since 1890, from the Gascoigne district, W.A., but as no data accompanied the specimens I was unable to identify them until Mr. Keartland recognised them by a nest he found during the progress of the ill-starred Calvert Expedition through North-western Australia. The nest was found on the 22nd October, 1896, about 7 feet from the ground, in a "cork"-tree, and was among the specimens left at the abandoned depôt in the desert. It is melancholy to reflect that this particular nest and single egg were found only a day or two before Mr. Keartland and Mr. G. L. Jones finally parted, the latter, as will be well remembered, perishing from thirst in the sand ridges of that terrible region.

However, another pair of eggs taken near the Fitzroy River, March, 1897, was received by Mr. Keartland.

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* P.L.S.N.S.W., vol. vii, p. 414 (1882).

Meliphaga phrygia, Latham.

"Warty-faced Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. IV, pl. 48.

Reference.—Cat. Bds. Brit. Mus., vol. IX, p. 221.

Previous Descriptions of Eggs.—Gould, Bds. of Australia (1848); also, Hdbk., vol., I, p. 528 (1865). Ramsay, Trans. Phil. Soc. N.S.W., with fig. (1865).

Geographical Distribution.—Queensland, New South Wales, Victoria, and South Australia.

Nest.—Cup-shaped, round; composed of strips of soft brownish bark, with an admixture of spider's greenish cocoons; inside lined with fine bark, grass, and soft materials, such as wool, hair, &c.; usually placed on a horizontal limb at the junction of a sprouting branch, or in a fork in rough-barked Eucalypts in open forest. Dimensions over all 4-4½ inches by 2 inches in depth, egg cavity, 2½ inches across by 1¼ inches deep.

Eggs.—Clutch 2; nearly oval in shape; texture fine; surface slightly glossy; colour, rich reddish-buff, darker on the apex, where is a zone of soft or indistinct spots of reddish and purplish-brown, a few spots also appearing over the rest of the surface. Dimensions of a clutch in parts in parts of an inch, (1) ·96 x ·67; (2) ·93 x ·67.

Observations.—As Gould remarks, the Warty-faced Honey-eater is not only one of the most handsome of our Honey-eaters, but one of the most beautiful of Australian birds. On account of the beauty of its black and golden plumage, it has been called the "Mock Regent-bird" in some localities.

The peculiar plaintive song, accompanied with the bowing of the head of the Warty-faced Honey-eater is very agreeable. The bird may be called an interior species, with a habitat ranging from Queensland down to South Australia, and although Gould regarded it as a stationary species, it occasionally, according to seasons, or the supply of the Eucalyptus blossom, wanders towards the coast. I recollect one season in November—1868 or 1869—when these birds were plentiful in the neighbourhood of Oakleigh and Murrumbeena, where we secured as many of their beautifully constructed bark-made nests, and lovely rich salmon-coloured eggs, as we needed. Again, in October, 1882, in the Bendigo district, I took their nests.

During the great drought in the interior—1896-7—the Warty-faced Honey-eaters were numerous in Victoria, and were noticed in localities where they had never previously been seen.

Gould somewhat qualifies his statement about the Warty-faced Honey-eater being a stationary species by stating, "I have occasionally seen flocks of from fifty to a hundred in number passing from

tree to tree as if engaged in a partial migration from one part of the country to another, or in search of a more abundant supply of food."

I myself have witnessed this once at Doncaster, Victoria, 2nd November, 1886, when a flock of about fifty swept past me across a valley*.

Mr. Hermann Lau writes:—"Mock Regent-bird. I first saw it at Goulburn (N.S.W.) 1855; then again at Pike's Creek, Queensland, 20 miles south-west of Warren. It only appears in numbers now and again. The site of its big nest is at about the height of 20 feet in a tree, and always near a thick stem or a few sprouting shoots. It is roughly made of coarse dry grass, lined with rootlets and animal hair. Deposits two or three eggs. Took nest, Pike's Creek, October, 1869."

Breeding month, end of September to December.

Ptilotis notata, Gould.

"Yellow-spotted Honey-eater."

Figure.—Gould, Bds. of Australia, fol. sup. pl. 41.

Reference.—Cat. Bds. Brit. Mus., ix, p. 227.

Previous Description of Eggs.—North, P.L.S.N.S.W., 2nd ser., vol. ix, p. 39 (1894).

Geographical Distribution.—Northern Territory and North Queensland; also New Guinea.

Nest.—Cup-shaped, deep; constructed of fibre coated with large pieces of paper-like Melaleuca bark; inside, chiefly the bottom, lined with a white cottony substance; placed in the forked branch usually of a low bush, but occasionally at the height of 30 feet from the ground, in scrub. Dimensions over all, $3\frac{1}{2}$–4 in. x $1\frac{3}{4}$–3 in. in depth; egg cavity, $2\frac{1}{2}$–3 in. across by $1\frac{1}{2}$–2 in. deep.

Eggs.—Clutch 2, rarely 3; oval, lengthened and compressed towards one end; texture exceedingly fine; surface very glossy; colour, pearly white, with a few pronounced or bold spots and roundish blotches of deep purplish-brown about the apex. Most resemble the eggs of the Yellow-eared Honey-eater (*P. lewini*). Dimensions, a clutch in parts of an inch, (1) ·9 x ·64; (2) ·88 x ·63.

Observations.—This Honey-eater is also known as *P. analoga* (Reichenbach), and a dozen other synonyms; but for the sake of simplicity I prefer to retain Gould's name, *P. notata*, which appears under a fine picture of the bird in his folio supplement.

The Yellow-spotted Honey-eater may be said to be the northern and smaller representative of the Yellow-eared (*P. lewini*). Gould says Gilbert collected a bird very nearly allied, if not the Yellow-

* One of Mr. C. C. Brittlebank's notes reads: "1st April, 1896. Flocks of Warty-faced Honey-eaters, thirty or forty birds in each, passed to the west about 9 a.m."

spotted Honey-eater, at Brown's Lagoon, on the 30th December, 1844, when travelling with Leichhardt from Moreton Bay to Port Essington.

During the Scientific Expedition to Bellenden-Ker Range (1889), the Yellow-spotted Honey-eater was found at all heights up to 4,000 feet.

Mr. A. J. North, who has accurately described the nest and eggs of this bird, states:—"Mr. Boyd (Herbert River) has also from time to time supplied me with the following information. A nest of this species he had under close observation from the time it was started until the young left the nest. It was a most curious position selected, the nest being built upon the frond of a fern 18 inches from the ground, growing in a fernery attached to Mr. Boyd's house, and opposite his office, to which people were constantly coming through the day; a piano also, that was in frequent use by the children, being within 15 feet of the nest. During the period of incubation the female sat steadily, and did not attempt to fly when looked at by one only 3 feet away, the nest being so deep that the whole of the bird's body was invisible except the bill. The bird was quite tame, and used to fly backwards and forwards through the dining-room when a number of persons were seated at dinner. The nest was commenced on the 7th December, and contained three eggs on the 15th; two young ones were hatched on the 28th, and a third next day—the period of incubation being fourteen days. The young birds left the nest on the 12th January."

Breeding season, September to March.

The following are the nests, each containing two eggs, taken at Cape York, by Mr. Harry Barnard, 1896–7, viz.:—In October, 1; November, 2; January, 2; February, 3; and March, 1.

PTILOTIS GRACILIS, Gould.

"Little Yellow-spotted Honey.eater."

Figure.—

Reference.—Gould, P.Z.S., 1866, p. 217.

Previous Description of Eggs.—(?) Ramsay, P.L.S.N.S.W., 2nd ser., vol. i, p. 1150 (1886).

Geographical Distribution.—Northern Queensland.

Nest.—Cup-shaped; comparatively small and roundish; composed of chiefly moss, ornamented outwardly with small pieces of grey bark, sometimes with a darker coloured bark and insect cocoons; neatly lined inside with a white silky substance; usually situated about 10 or 12 feet from the ground, in scrub. Dimensions over all, 2½–3 inches by 1¾–3 inches in depth; egg cavity, 2½ inches across by 1½ inches deep.

Eggs.—Clutch, 2; oval, slightly compressed towards one end; texture fine, surface slightly glossy; colour, rich fleshy tint or

salmon pink, marked moderately but somewhat boldly, and particularly round the upper quarter, with rich pinkish-chestnut and a few purplish spots. The eggs, being amongst the most richly-coloured of Australian Honey-eaters', are exceedingly beautiful. Dimensions of a clutch, in parts of an inch: (1) ·8 x ·6; (2) ·79 x ·6.

Observations.—As already mentioned, there have been more synonyms and confusion than enough, so much have doctors differed about the identification of the Yellow-spotted Honey-eaters of Northern Australia and contiguous localities.

Finally, Dr. Sharpe has classified them into three races according to geographical distribution. Whether there be races, varieties, or species, from an oological point of view (which is a somewhat sound one, for "by their fruits ye shall know them"), there are certainly two distinct Yellow-spotted Honey-eaters other than *P. lewini* inhabiting Northern Queensland, and which it appears Gould has clearly pointed out—first, the larger bird, *P. notata*, and second, the smaller species, *P. gracilis*. The birds are precisely similar in appearance save in size; yet while the eggs of the former resemble those of its southern cousin, *P. lewini*, being white, with a few dark spots, the others, besides being proportionately smaller, are a fleshy tint and richly coloured. The decided difference in the two classes would appear constant, judging by the series of eggs, identified by skins of both kinds of birds shot from the nests, which I had the opportunity of examining with Mr. Dudley Le Souëf, at the Zoological Gardens, Melbourne.

When collecting at Cape York, 1896–7 season, Mr. Harry Barnard took nine or ten nests, each containing two eggs of *P. notata*, and four nests—three each two eggs, the other a single—of *P. gracilis*. There are also birds and eggs of both kinds in the collection of Mr. Le Souëf, which he brought down from the Bloomfield River district.

I hardly know that I am correct in giving as a reference Dr. Ramsay's description of the eggs taken near Cairns by Mr. Boyer-Bower as belonging to those of the smaller species. The rich colouration—"nearest to those of *P. auricomis*"—agrees, but not the dimensions.

Breeding month for the Little Yellow-spotted Honey-eater, October to January.

PTILOTIS FUSCA, Gould.

"Fuscous Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 44.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 229.

Previous Descriptions of Eggs.—Ramsay, Trans. Phil. Soc. New South Wales, with fig. (1865). Campbell, Southern Science Record (1883).

Geographical Distribution.—Queensland, New South Wales and Victoria.

Nest.—Cup-shaped, neat; composed of shreds of bark matted with spider's web and cocoons; lined inside with fine shreds of bark, a few rootlets, hair, and sometimes the silky down from seed vessels or cotton material gathered in the neighbourhood of habitations; usually placed among the branchlets at the end of a horizontal Eucalyptus bough. Dimensions over all $2\frac{1}{2}$ inches by 2 inches in depth, egg cavity 2 inches across by $1\frac{1}{4}$ deep.

Eggs.—Clutch 1–3, but usually 2; oval, compressed towards one end; texture of shell fine; surface has a faint trace of gloss; colour, rich salmon on buff, marked more or less distinctly about the apex with pinkish-red and purplish-brown. Dimensions in parts of an inch of odd examples—(1) ·77 x 56; (2) ·75 x ·55.

Observations.—The range of the Fuscous Honey-eater extends from Northern Queensland down to probably South Australia.

Although this Honey-eater is not distinguished by any brilliancy of colour, Gould has painted it in a pretty word picture. Referring to the bird in the brushes of New South Wales, he says, "In the months of August and September, when the beautiful *Tecoma* is in blossom, the Honey-eater may be seen flitting about among the thick clusters of the pendant flowers in search of insects, which are sometimes captured on the wing, but more generally extracted from the tubular florets."

In the Bendigo district, Victoria, towards the Campaspie River, I once came upon quite a number of Fuscous Honey-eaters feeding upon Grevillea bushes that grew in a snug hollow in an Ironbark (Eucalypt) forest. I did not see a nest, however, until I went to Coomooboolaroo, Queensland, where I observed one suspended among the flowering branchlets of a Eucalytus near the lagoon.

The Messrs. Barnard informed me that like many other birds, the Fuscous Honey-eater lays according to the season; if droughty one or two eggs are laid, if the season be good three are deposited. Once a clutch of four was taken which is, of course, an exceptional complement.

Breeding months, August to December, or later.

PTILOTIS LEWINI, Swainson.

"Yellow-eared Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 32.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 229.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk, vol. i, p. 504 (1865). Ramsay, P.Z.S., p. 595 (1875). North, Cat. Nests and Eggs, Austn. Mus., p. 199 (1889).

Geographical Distribution.—Queensland, N. S. Wales, and Victoria.

Nest.—Cup-shaped, deep, with substantial walls; constructed chiefly of strips of bark (Melaleuca, &c.), and spiders' cocoons, generally outwardly beautifully covered with moss; lined inside with thick warm ply of a downy or silky substance, such as thistle down or other soft seeds, varying in colour—white, brown, or yellowish—according to the locality or the species of plant from which the seeds are gathered; usually attached to the twigs of a thick bush or tree in scrub and forest country alike. Dimensions over all, $3\frac{1}{2}$–4 inches by $2\frac{1}{2}$–3 inches in depth; egg cavity, $2\frac{1}{4}$–$2\frac{1}{2}$ inches across by $1\frac{1}{2}$–$1\frac{3}{4}$ inches deep.

Eggs.—Clutch, 2–3, usually the former number; nearly true oval in shape; texture of shell fine; surface slightly glossy; colour white, very sparingly marked with spots and dots of dark purplish-brown, almost black, most of the markings being on the apex or about the upper quarter. Dimensions of a clutch in parts of an inch: (1) ·96 x ·7; (2) ·96 x ·7.

Observations.—This fine Honey-eater is common to the forests and scrubs of Eastern Australia, chiefly in the coastal region. It is doubtful whether they are found at Cape York. I am not certain whether they frequent the Cape Otway forest, but I have observed the bird as far south as the Dandenongs, near Melbourne, where I have often heard, as Gould describes it, the loud, ringing, whistling song of the bird. In Gippsland in the autumn I have observed Lewin's or the Yellow-eared Honey-eater feeding in the forest clearings on the fruit of the so called Kangaroo-apple bush *(Solanum)*.

The first nest I found of this species was in October, 1885. It was about 10 or 12 feet from the ground in scrub, near the Fitzroy River (Q.). The eggs, however, were addled, but there was no mistaking the identity of them and the nest, with its beautiful lining of white silky substance.

The next nest that came under my observation was in the "Big Scrub," Richmond River (N.S.W.), where the birds are exceedingly numerous, and where I often admired their graceful actions while pirouetting in mid-air after insects. The nest, which contained two eggs, was brought to me by scrub-fallers, who reported that it originally contained three eggs (the number being usually a pair), and was taken in a thick bush, about 4 feet from the ground. The nest was constructed of moss and dead leaves, and was lined with grass and a thick warm ply of thistle-down. Date, 18/11 91.

Gould describes a nest—the first recorded of this species—he found prettily situated in a creeper which overhung a small pool of water in a gully under the Liverpool Range.

According to the Australian Museum "Descriptive Catalogue," Dr. Ramsay, on the 29th December, 1871, took two eggs on the

Mary River (Q.), which were probably the specimens referred to in the P.Z.S. (1875), but for which no dimensions were furnished.

A nest of the Yellow-eared Honey-eater, taken near Melbourne in a Musk-tree in the Dandenongs, is large and composed of beautiful green moss interlaced with strips of brownish-coloured bark and lined inside with a thick ply of the whitish cotton-like substance evidently gathered from the underside of the leaves of the Blanket-wood (*Senecio*). Dimensions—outward, 4–5 inches across by 4 inches deep; inside, 2½–3 inches across by 2 inches deep. Near the same locality, after a picnic party had departed, I, and some other persons, were entertained by one of the fine Honey-eaters, which descended close by and ate, with a relish, some particles of preserved fruit that were left.

Breeding months, September to December or January.

PTILOTIS FRENATA, Ramsay.

"Bridled Honey-eater."

Figure.—Gould–Sharpe, Bds. of New Guinea, vol. iii, pl. 49.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 231.

Previous Descriptions of Eggs.—North, Records Australian Museum, vol. ii (1892).

Geographical Distribution.—North Queensland.

Nest.—Cup-shaped; composed of long pliant stems of a climbing plant and portions of the soft reddish-brown stems of a small fern; inside neatly lined with a white, wiry, vegetable fibre, forming a strong contrast to the reddish-brown colour of the exterior. Dimensions over all, 4·25 inches by 2·6 inches in depth; egg cavity, 2·5 inches across by 1·6 inches deep (North).

Eggs.—Clutch, 2; oval in form, tapering gradually to the smaller end, and are white with minute dots and round markings of purplish-black and brownish-grey, the latter colour appearing as if beneath the surface of the shell; as usual the markings predominate on the thicker end, where in places they become confluent and form an irregular zone; with the exception of these zones the markings on one of the specimens are larger and more sparingly dispersed, in the other they are uniformly distributed over the greater portion of the surface of the shell. Dimensions in inches—(1) ·93 x ·65; (2) ·95 x ·65 (North).

Observations.—This very fine northern Honey-eater is only known to exist in the Rockingham Bay district, chiefly in the ranges. It is found as far north as the Bloomfield River. Mr. Kendal Broadbent, when collecting for Dr. Ramsay, first found the species in the Cardwell district, where a few individuals were obtained frequenting blossoming Eucalypts near the margin of a swamp.

I think it was this species we found in Dalrymple's Gap feasting in numbers upon the heads of long, erect, flowering spikes of a dark-red colour of the graceful Umbrella-tree (*Brassaia*).

Through the "Records" of the Australian Museum we learn that the first recorded nest of the Bridled Honey-eater was found by Mr. W. S. Day at Cairns, on the 28th November, 1891. It was placed in a mass of creepers growing over a small shrub at a height of about 3 feet from the ground. The nest was built of stronger materials than is usual for the species, and unattached at the rim. The eggs (two), which were partially incubated, were also unlike those typical of *Ptilotes*, approaching nearer in colour and the disposition of their markings those of some members of the Wood Swallows (*Artami*). The parents were also procured.

Ptilotis flavo-striata, Gould.

"Yellow-streaked Honey-eater."

Figure.—Gould–Sharpe, Bds. of New Guinea, vol. iii, pl. 50.
Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 232.
Geographical Distribution.—North Queensland.
Nest and Eggs.—Unknown.
Observations.—This rare species was procured in the Rockingham Bay district and forwarded to Gould for examination by Mr. Waller, of Brisbane. The name *flavo-striata* is suggested by the yellow chest-streaks which are such a conspicuous feature in the bird's appearance.

Ptilotis sonora, Gould.

"Singing Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 33.
Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 234.
Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 505 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 200 (1889).
Geographical Distribution.—Australia in general, especially the interior.
Nest.—Cup-shaped, deep; in Western Australia substantially interwoven and constructed of strong green-gathered grass, lined inside with wool, cow-hair, long horse-hairs, &c.; usually suspended in a bush or tree in open forest country. Dimensions, $3\frac{1}{2}$ inches over all by 3 inches in depth; egg cavity 2 inches across by $1\frac{3}{4}$ inch deep.

In eastern parts the nest is somewhat thinner; the grass being matted with spider's web, while the lining is fibrous rootlets. Dimensions, over all, $2\frac{1}{2}$ inches by $1\frac{1}{4}$ inch in depth; egg cavity, 2 inches across by 1 inch deep.

Eggs.—Clutch, 2–3; oval in shape, more or less compressed towards one end; texture of shell, fine; colour, a delicate pinkish buff, or beautiful fleshy tint having the appearance of a darker shade in the form of a cap on the apex, this dark patch being really

formed by a coalescence of numerous indistinct specks. At first sight the eggs closely resemble those of the Pallid Cuckoo (*C. pallidus*). Dimensions of a clutch in parts of an inch (1) ·81 x ·6; (2) ·81 x ·6; (3) ·8 x ·59.

Observations.—I do not think any Honey-eater enjoys such a widespread range as the Singing Honey-eater, which has been observed in almost every part of the continent, the heavier-forested parts excepted. I have had the pleasure of finding their nests and delicately coloured flesh-tinted eggs, both in the east and in the west of Australia, therefore I am able to attest to the difference of structure (the nests of the western birds being the heavier built) as pointed out by Gould.

The first nest I took (October, 1885) was in the Mallee country near Nhill, Victoria, when I observed the birds building in a "Bull-oak" (*Casuarina*), and subsequently obtained a pair of beautiful eggs from it. My last find was a well-built nest placed a few feet from the ground in a short growth of ti-tree (Melaleuca) scrub, Quindalup (W.A.). This nest, from which I flushed the bird, contained a lovely set of 3 eggs. The Singing Honey-eater is one of the most common birds I met with in Western Australia. It is found breeding in orchards, where I noticed old nests in orange and lemon trees. In one garden I watched a fine bird clinging to a large head of bluish flowers (*Echium*) busily probing each flower for honey with the same rapidity as a domestic fowl would pick up grain.

Why is the bird called the "Singing" Honey-eater? Gould says its song is "full, clear, and loud." All I could ever hear, save a few shattering notes, was "Cr-rook, cr-rook," uttered while the bird, with graceful flight, passed from tree to tree.

Mr. Hermann Lau, in his MS. notes from Darling Downs (Q.), says:—"*Ptilotis vittata (sonora)*, locally called the Large-striped Honey-eater, gets its name from the yellow line over the eyes. This bird loves hanging its cradle on the lower branches of a *Casuarina*, near water, on the outskirts of a thicket. The cradle, or rather hammock, is made of grass with rootlets for a floor; has sometimes three eggs. Cunningham's Gap, October, 1876."

Writing to me from Yorke Peninsula (S.A.), Mr. James G. McDougall includes a curious note:—"The Singing Honey-eater builds a small and airy nest of wool, hair, and fine grass interlaced with twigs of Ti-tree and She oak without lining; eggs, two, but sometimes three. In October, 1886, I found a nest of this bird tenanted by two hens and containing five eggs, three of which were the usual colour and two pure white."

In the Australian Museum "Catalogue," Mr. A. J. North gives field notes of the late Mr. K. H. Bennett, respecting the nest of the Singing Honey-eater, and describes eggs collected by Mr. James Ramsay (1880) and by the late Mr. W. Liscombe (1883).

Breeding season includes the months from the end of July or the beginning of August to December. Several clutches of these eggs were taken in West Australia by the Calvert Expedition during August, 1896. Occasionally they were the only kinds observed on the sandhills.

PTILOTIS VERSICOLOR, Gould.

"Varied Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 34.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 234.

Geographical Distribution.—North Queensland and New Guinea.

Nest and Eggs.—Unknown.

Observations.—The Varied Honey-eater is one of the finest species of its family. Little is known of its economy. Dr. Ramsay's *P. Macleayana* is synonymous with it.

PTILOTIS CHRYSOPS, Latham.

"Yellow-faced Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 45.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 236.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i. p. 521 (1865). North, Cat. Nests and Eggs Austn. Mus., p. 208 (1889).

Geographical Distribution. — Queensland, New South Wales, Victoria, and South Australia.

Nest.—Elegant, cup-shaped, deep with swollen sides; somewhat frailly constructed of fine curly pieces of beautiful moss intermingled with spiders' web, sometimes with fine shreds of bark added; inside lined with very fine light-coloured rootlets and pieces of grass; usually situated in a low bush, particularly a *Melaleuca* or *Leptospermum* overhanging a stream, or sometimes sewn, as it were, by the rim with cobweb to a fern (bracken) frond. Dimensions over all 3 inches by 2½ inches in depth; egg cavity 2 inches across by 2 inches deep.

Eggs.—Clutch, 2–3; lengthened in form; texture fine; surface slightly glossy; colour, light reddish or pinkish-buff, marked and freckled all over, and in a confluent patch round the apex, with rich reddish-chestnut and purplish-grey; the eggs are singular for this genus, and somewhat resemble those of the Minah (*Myzantha garrula*) in miniature. However, some examples are whiter in the ground colour, with round spots about the apex. Dimensions of a clutch in parts of an inch: (1) ·82 x ·57; (2) ·74 x ·54.

Observations.—This cheerful Yellow-faced Honey-eater, as Gould states, may be regarded as a common species, and inhabits all the

eastern colonies, more particularly the coastal regions. It is very destructive to fruit, and is especially fond of grapes. Mr. North writes it is one of the most common species of the genus *Ptilotis* inhabiting the parks and gardens of Sydney. It is probably nowhere more numerous than in Victoria, where it may be heard (often at early morn) by its happy, chirrup-like song, near forest streams, or in scrub by river's margin.

The moss-bedecked nest and the typical red mottled eggs of the Yellow-faced Honey-eater are exceedingly beautiful. Many I have found, notably at Lilydale and Upper Werribee. At the latter locality I specially remember a very pretty one situated in a charming spot. It was suspended in an Acacia bush in blossom that hung over a moss-covered bank of a dry watercourse in a silent and sheltered nook of an Ironbark forest. (Date 11–10–90.) The first nest of this species I took was at Malvern, 1869. The eggs were the exceptional type, more distinctly spotted, like those of its White-plumed cousin (*P. penicillata*). The only other eggs I found of this type were obtained at Berwick, January, 1880.

Gould found a nest near the Liverpool Ranges, which was so thinly constructed that he could see through it. Such examples I have noticed myself, when the eggs could be seen from beneath.

Mr. Hermann Lau's observations of the Yellow-faced Honey-eater in southern Queensland are that it is usually found in the sea-coast scrubs, and places its nest in a small bush, 4 or 6 feet high. The nest consists of dry grass outside, and feathers and rootlets for lining ; lays two eggs.—Cunningham's Gap, October, 1876.

The little Yellow-faced Honey-eater is not only lively and cheerful, but is persevering, as the following observations of Mr. and Mrs. De Laney attest. On the Wombat Creek, near Omeo, Victoria, a pair built in a shapely Blackwood (Acacia) in the garden. As the site was rather near the fruit trees, the nest and eggs were taken, but next day in the same tree a new nest was found nearly completed, both birds working at it, and before the week was out had eggs. Again the nest was robbed, and so on for six times, each clutch being the full complement of three eggs. However, the seventh time (there is luck in odd numbers, as the saying goes) the birds won by building a nest near the ground in a low bush about ten paces distant from the Blackwood tree, which was not discovered till it contained young.

Breeding months, July to February. Mr. C. C. Brittlebank and I observed birds building a nest on the bank of the Lerderderg River, 6 Feb. (1892). Mr. C. F. Belcher, in his pleasantly written article in the "Wombat," "Notes on birds of the Geelong District," mentions a pair of eggs he took at Lake Connewarre as late as the 12 Feb. (1890).

PTILOTIS FILIGERA, Gould.

"Streak-naped Honey-eater."

Figure.—Gould, Bds. of Australia, fol., sup., pl. 42.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 237.

Nest and Eggs.—Unknown.

Geographical Distribution.—Northern Territory and North Queensland, also New Guinea and Aru Islands.

Observations.—Gould reckoned that the Streak-naped Honey-eater was more nearly allied to the White-gaped Honeyeater (*P. unicolor*) than to any other, but is strikingly different from all its congeners by the thread-like streak beneath the ear coverts, and by the small striæ which decorate the back of the neck, hence the very appropriate vernacular name, Streak-naped Honey-eater.

The original specimens described by Gould were among the novelties which rewarded the researches of Mr. James Wilcox, who obtained two examples among the mangroves at Cape York.

PTILOTIS FLAVIGULARIS, Gould.

"Yellow-throated Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 35.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 239.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 509 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 201 (1889), also Rec. Aust. Mus., vol. i (1891).

Geographical Distribution.—Tasmania, and some of the larger islands in Bass Straits, notably King and Flinders.

Nest.—Cup-shaped, deep; outwardly constructed of bark (*Melaleuca*), fine twigs, grass, and spiders' cocoons; inside warmly lined with fur, hair, wool, &c.; usually placed low in a thick bush or in scrub. The nest is not unlike that of *P. leucotis* of the mainland. Dimensions over all 4 inches by $3\frac{1}{2}$ deep; egg cavity, $2\frac{1}{4}$ inches across by 2 deep.

Eggs.—Clutch 2–3 (3–4, Brent); oval in shape, compressed towards one end; texture of shell fine; surface slightly glossy; colour, warm or pinkish-white, sparingly spotted with reddish-brown or chestnut and purplish-grey. Dimensions of odd examples in parts of an inch (1) ·93 x ·7; (2) ·91 x ·67.

Observations.—The exceedingly fine Yellow-throated Honey-eater is well named for its beautiful colouring upon the throat. It is an insular form confined to Tasmania and some of the islands in Bass Straits, notably King Island and Flinders Group. In the last-named localities we procured birds and nests during the expeditions (1887 and 1893) of the Field Naturalists' Club of Victoria.

On King Island two nests were found in low bushes, and were warmly furnished with a thick ply of opossum's fur. Our specimens of birds were easily procured. All that was necessary was

to imitate their whistle-like "tchook, tchook" call notes, when a poor bird would often answer and fly into the tree overhead its deceiver, from whence it easily fell to a half charge of dust shot.

Strolling through the scrub on Flinders, I watched a pair of Yellow-throats chevying each other through the trees. A butterfly crosses in front, diverting the attention of the foremost bird, which instantly captures it and flies to a tree. Devouring the insect, the bird wipes its bill on the branch, with evident satisfaction, and makes off again.

An unoccupied nest I found in a Ti-tree thicket is not unlike that of the White-eared Honey-eater of the mainland, being constructed of bark, grass, and spiders' cocoons, but lined with wool and feathers instead of hair only. However, in Tasmania the Yellow-throated Honey-eater has been seen gathering hair for its nest from live animals—even "human" animals—for Mr. A. E. Brent gives me the following amusing story:—

He and a companion were in hiding among ferns (bracken) in a deep gully watching for hawks. A Yellow-throated Honey-eater was noticed poking about as if it had a nest near. They took off their hats so as not to attract the bird's attention. The bird hopped around, then alighted upon one of their heads, and commenced tugging at the hair, which would not yield like the fur of a marsupial. The bird tugged harder, but the hair slipping through its bill caused the bird to turn a semi-somersault backwards, which made Mr. Brent and his companion laugh so that the bird was scared away. The nest in process of building was found about 15 paces away.

Gould found a nest containing young (28th September, 1839). He also described the nest, its situation, and eggs.

Breeding months, August to December.

Ptilotis fasciogularis, Gould.

"Fasciated Honey-eater."

Figure.—Gould, Bds. of Australia, fol. sup. iv, pl. 40.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 240.

Geographical Distribution.—Queensland.

Nest and Eggs.—Unknown.

Observations.—These finely-shaped Honey-eaters, which, as Gould points out, differ from the other members of the genus in the distinct bars of pale yellow and brown which mark the throat and fore part of the neck, are generally found in belts of mangroves on the Queensland coast, and adjacent low, swampy islands, and are sometimes called the Island Honey-eater. During an excursion with Mr. A. W. Milligan, on the Lower Fitzroy, we found the birds making the mangroves merry with their pleasant notes. The birds were extremely shy, nevertheless we succeeded in procuring a couple of skins.

PTILOTIS LEUCOTIS, Latham.

"White-eared Honey-eater."

Figure.—Gould, Bds. of Australia, fol. vol. iv, pl. 36.

Reference.—Cat. Bds., Brit. Mus., vol. ix, p. 240.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883). North, Cat. Nests and Eggs, Austn. Mus., p. 201 (1889); also app. ii (1890).

Geographical Distribution.—Australia in general, except north.

Nest.—Cup-shaped, deep; well constructed of fine bark and grass, matted together with spiders' cocoons; lined inside with a warm ply of cow or other hair; usually placed near the ground in a thick bush or in low scrub. Dimensions over all $3\frac{1}{2}$ to 4 inches, by $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in depth; egg cavity 2 inches across by $1\frac{1}{2}$ inch deep.

Eggs.—Clutch, 2 usually; oval, compressed towards one end; texture fine, surface slightly glossy; colour, almost white, but sometimes of a delicate flesh tint, sparingly but distinctly marked and spotted with pinkish-red, the spots being more about the upper quarter. Dimensions of a clutch in parts of an inch: (1) ·86 x ·64; (2) ·85 x ·63.

Observations.—This fine, showy Honey-eater, with conspicuous white ears, is not an uncommon bird in lightly timbered and heathy tracts of country in Victoria and other southern parts. It is a scarce bird in Western Australia. I fancy Dr. Ramsay's north-west habitat for this species needs verification.

The bird is an early breeder. I had always to be afield in the coastal scrubs about the beginning of September if I wanted fresh eggs. The nest is difficult to find amongst the acres of thick, short scrub, and frequently is only detected by watching the movements of the bird, which at all times is exceedingly wily. My greatest find of White-eared Honey-eaters' nests in one season was in 1883, if I recollect rightly—the year when I found three nests all situated about a foot from the ground, and lined with a thick warm ply of cow-hairs wonderfully woven.

It is interesting to watch the birds plucking hair off while perched on the backs of cattle, and rather a difficult task it proves for the bird to effect lodgment, especially if the cow patronised be not in an amiable mood, when she tosses her head angrily and switches her tail from flank to neck, while the bird, fluttering over, waits an opportunity to dodge the cow's tail, and between each lash plucks a few hairs till a mouthful is obtained, then flies to its nest.

Mr. G. E. Shepherd, Somerville, Victoria, has enjoyed a somewhat comical experience with nest-building White-eared Honey-eaters. They have actually plucked hairs from his horse when he was riding through the country.

No doubt before cattle were introduced to Australia this beautiful Honey-eater furnished its nest with the hair or fur of kangaroos and other indigenous animals.

Mr. C. F. Belcher has observed that the same pair of White-eared Honey-eaters will build within a few feet of the same spot year after year.

Breeding months, from the end of August to December.

Ptilotis cockerelli, Gould.

"Cockerell Honey-eater."

Figure.—Gould, Bds. of Australia, fol., sup. pl. 43.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 241.

Geographical Distribution.—North Queensland.

Nest and Eggs.—Unknown.

Observations.—Of this rare honey-eater Gould writes:—"It is but an act of justice that at least one of the birds of Australia should be named after Mr. James Cockerell, inasmuch as he is a native born Australian, has collected very largely in the northern parts of that great country, and discovered more than one new species, amongst which must be enumerated the present very interesting bird."

Mr. Cockerell found his namesake frequenting the little-explored parts of Cape York Peninsula, often in company with the Blue-bellied Lorikeet and the Yellow-spotted Honey-eater.

When Mr. Harry Barnard was collecting for Mr. D. Le Souëf and others during the breeding season of 1896-7, at Cape York, he met with the Cockerell Honey-eater, but did not succeed in procuring its nest.

Ptilotis auricomis, Latham.

"Yellow-tufted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 37.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 242.

Previous Descriptions of Eggs.—Ramsay, Ibis, vol. vi (1864), *id.* Gould, Bds. of Aust. Hdbk., vol. i, p. 512 (1865).

Geographical Distribution.—Queensland, New South Wales, and Victoria.

Nest.—Cup-shaped, substantial; constructed of fine strips of brownish-coloured bark (chiefly), and grass matted with cocoons, sometimes of various colours; inside lined with grass, and on the bottom with soft seeds—thistle, Clematis, &c.; usually suspended in a creeper, sapling, or small tree in open forest country. Dimensions, 3½-4 inches over all x 2¼-3 inches in depth; egg-cavity 2¼-2½ inches x 1½-2 inches deep.

Eggs.—Clutch, 2-3; short in form, abruptly compressed towards one end; texture, fine; faint trace of gloss on surface; colour, rich

or pinkish-buff, darker on the apex; moderately and finely spotted with pinkish-red and purplish-grey, the majority of the markings being about the larger end. Dimensions of a clutch in parts of an inch: (1) ·85 x ·66; (2) ·82 x ·63.

Observations.—This exceedingly handsome and attractive Honey-eater favours the more inland portions of South Queensland, New South Wales, and Victoria, and especially loves Ironbark (Eucalypt) forests.

Some species of Honey-eaters are gregarious at times. Towards the end of our summer (March, 1889) I witnessed the unusual sight of about 100 or more of the beautiful Yellow-tufted Honey-eaters flying in a flock northward across the rich flats of Bacchus Marsh.

I have observed Yellow-tufted Honey-eaters nesting in the Ironbark saplings near Bendigo, also on the Upper Werribee, but was always unfortunate in the matter of securing eggs. A nest from the latter locality, found in a Golden Wattle (Acacia) sapling, was somewhat large, deep, and firmly built of fine strips of reddish strings of bark, together with spiders' cocoons, and was lined inside with finer shreds of the same coloured bark, thistle-down, and such-like soft seeds.

The eggs in my collection are from Dr. Ramsay, who has enjoyed early and delightful nesting experiences with this beautiful Honey-eater, and whose remarks I make no apology for quoting at length: "This species remains with us in the neighbourhood of Sydney throughout the whole year, breeding earlier than the generality of Honey-eaters. We have eggs in our collection taken early in June, and as late as the end of October, during which month they sometimes have a third brood. August and September seem to be their principal months for breeding. Upon referring to my note-book, I find that I captured two young birds well able to fly, on the 18th of July, 1863; but during some seasons birds breed here much earlier than in others. The nest is a neat but somewhat bulky structure, open above, and composed of strips of the Stringy-bark tree (*Eucalyptus obliqua*). The total length of the nest is about four inches by from two inches and a-half to three inches wide, being two inches deep by one inch and a-half inside. The eggs, which are usually two in number, are of a pale flesh-pink, darker at the larger end, where they are spotted and blotched with markings of a much deeper hue, inclining to salmon-colour; in some the markings form a ring upon the thick end, in others, one irregular patch with a few dots upon the rest of the surface. When freshly taken, they have a beautiful blush of pink, which they generally lose a few days after being blown. Their length is from ten to eleven lines by seven to eight in breadth. Some varieties have a few obsolete dots of faint lilac; others are without markings, save one patch at the top of the larger end. Like most of our Australian birds' eggs, they vary much in shape and

tint of colour. The site selected for the nest is usually some low bushy shrub, among the rich clusters of *Tecoma australis*, or carefully hidden in the thick tufts of *Blechnum* (*B. cartilagineum*), which often cover a space of many square yards. In these clumps, where it clings to the stems of ferns, I have several times found two or three pairs breeding at the same time within a few yards of each other. The ferns and *Tecomæ* seem to be their favourite places for breeding, although the nests may often be found placed suspended between forks in the small bushy oaks (*Casuarinæ*). In the nest of this Honey-eater, I have several times found the egg of the *Cuculus inornatus (pallidus)*."

The following is an interesting note kindly sent to me by Mr. C. C. Brittlebank:—"Yellow-tufted Honey-eaters' nests have been observed in the trees and shrubs as under: 'Old-man' Saltbush, about three feet from the ground (9th November—young); Wattle-tree, about seven feet from the ground; Ironbark (Eucalypt), at about forty feet; Aster, with a leaf like Rosemary (18 October—eggs); Gray-box (Eucalypt), about fifty feet high (26 October—old birds feeding young). Nests in all cases were built of moss, root-fibres, grass, and spiders' cocoons. In one instance the birds were working at their nests while I was within 6 feet of them. The nests as built here greatly resembles that of the Yellow-faced Honey-eater (*P. chrysops*), but are thicker towards the bottom. One nest had several pieces of bark woven through the structure and over the branches to which it hung. Have only seen these nests in one part of this district (the Upper Werribee River), and only in a tract of country about half a square mile in extent."

PTILOTIS CASSIDIX, Jardine.

"Helmeted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 39.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 243.

Previous Description of Eggs.—Campbell, Southern Science Record (1885).

Geographical Distribution.—Victoria.

Nest.—Substantial, cup-shaped, deep, with bulging sides; constructed of soft strings or strips of brownish bark (*E. obliqua*), with a few spider's cocoons and a leaf or two inserted; inside lined with fine bark and other soft material such as hair, Clematis seeds, &c.; usually suspended in the branch of a low tree or bush near or overhanging a stream, in thick forest. Dimensions over all, $3\frac{1}{2}$ to 4 inches by 4 inches in depth; egg cavity, $2\frac{1}{4}$ inches across by $2\frac{3}{8}$ inches deep.

Eggs.—Clutch, 2; well-shaped, oval, slightly compressed towards one end; texture, fine; surface, slightly glossy; colour of a fleshy

tint, moderately marked with reddish or pinkish-brown, and dull purplish spots, more numerous about the apex. Dimensions of two clutches in parts of an inch. A—(1) ·95 x ·69 ; (2) ·94 x ·68 ; B—(1) ·92 x ·63 ; (2) ·91 x ·64.

Observations.—The Helmeted or Leadbeater's Honey-eater is perhaps the rarest and the most splendid bird of its genus. It was brought to scientific light in a peculiar way. Gould's friend, Sir William Jardine, sent him a specimen obtained in Edinburgh from among a collection of ordinary Australian species. The new bird was exhibited at a meeting of the London Zoological Society, December, 1866.

The Helmeted Honey-eater has a somewhat local habitat, confined to the great forests of Gippsland, where no doubt it takes the place of its more inland congener, the beautiful Tufted Honey-eater (*P. auricomis*), which it resembles. Like the Tufted, the Helmeted is gregarious at seasons ; Mr. A. W. Milligan informed me he had seen a large flock in the vicinity of Olinda Creek, near Lilydale.

It was at that creek that the only three authenticated nests have been discovered. The first and historical nest being found during the first camp-out of the Field Naturalists' Club of Victoria, November, 1884. I was aware these fine birds existed in a certain patch of Native Hazel (*Pomaderris*) scrub, where on several occasions I made attempts, but failed to discover their breeding-place. The camp-out having formed themselves into parties, I piloted the oologists to the hazel patch, which was hardly entered before the honor fell to the late Mr. W. Hatton of detecting the first nest with the rare Honey-eater sitting. The nest was situated at a height of about 20 feet, and was suspended to an out-stretched branch of a Hazel overhanging the creek. With what ecstacy of delight the small tree was ascended ! The handsome bird still retained possession of its nest. With Mr. Hatton's assistance, I all but had my hands on the coveted prize, when, without a moment's warning, crash went the tree by the root, and all—the two naturalists, tree, bird, nest, and eggs—went headlong into the stream beneath. Alas ! I thought, farewell to the eggs of *Ptilotis cassidix*. So near and yet so far ! But imagine our astonishment when, after dragging ourselves out of the water, and removing some of the fallen *débris*, to find nest and eggs intact —thanks to the poor bird, which bravely stuck to its home till overwhelmed by the falling foliage. The eggs, in which incubation had just commenced, were beautiful specimens, and are now in my cabinet.

The second nest was discovered by two field naturalists the following season, near the same locality, also in a Hazel, overhanging the stream, while the third nest I found 9th October, 1886, in the same creek, but nearer Lilydale. By bending the bush or

small tree, this nest was reached from the ground. The eggs—a pair—were perfectly fresh, and now adorn the collection at the National Museum, Melbourne.

Breeding months are most likely from September to December.

Ptilotis cratitia, Gould.

"Wattle-cheeked Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 38.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 243.

Geographical Distribution. — Northern Territory, Victoria, South and West Australia.

Nest.—Most resembles that of *P. sonora* (Singing Honey-eater), being somewhat thinly constructed of grass matted with spider's web, &c., and suspended in a bush or low tree.

Eggs.—Unknown.

Observations.—The Wattled-cheeked Honey-eater has been chiefly found along the southern part of Australia, where it seems to love the timber of the drier country.

Gould first found it as a new species on the 26th June, 1839, in the ranges near the Upper Torrens, in South Australia.

When hunting for Mallee-hen mounds in the Wimmera District, Victoria, I met with this Honey-eater in the scrub, and observed a bird building low (within reach) in a Mallee tree. The birds, which were fairly numerous, were noisy, but shy.

This honey-eater may be distinguished from all of its kind by the stripes of beautiful, lilac-coloured, naked skin which stretches from the corner of the mouth, and extends down the sides of the cheeks; hence the vernacular name—"Wattle-cheeked."

Ptilotis keartlandi.

"Keartland Honey-eater."

Figure and Reference.—North, Report Horn Scientific Expedition.

Previous Description of Eggs.—North, Report Horn Scientific Expedition, p. 94 (1896).

Geographical Distribution.—South (Central), West, and North-west Australia.

Nest.—Not unlike that of *P. sonora* (Singing Honey-eater).

Eggs.—Clutch, 2 usually; inclined to be lengthened and oval in form; texture, fine; surface, glossy; colour, pale flesh tint or light pinkish-buff, sparingly marked with a few indistinct reddish spots in the form of a belt round the apex. Most resemble those of *P. sonora.* Dimensions of a clutch in parts of an inch: (1) ·88 x ·6; (2) ·85 x ·58; an odd example, ·89 x ·68.

Observations.—In a small parcel of skins collected by Mr. Tom. Carter in the vicinity of the North-west Cape about 1890, I received one skin of this Honey-eater. I did not pay much attention to it at the time beyond taking it to be a variety of the Singing Honey-eater.

Mr. G. A. Keartland found the same kind of bird in Central Australia during the Horn Scientific Exploring Expedition, 1895, and Mr. A. J. North, who was entrusted to examine all the skins collected by the expedition, recognised a specific difference in the Honey-eater and dedicated it to Mr. Keartland, a compliment richly deserved for his enthusiasm as a field ornithologist.

In 1896 Mr. Keartland again met his namesake in some scattered Mallee near the tropical line in Western Australia during the unfortunate expedition promoted by Mr. Calvert.

Ptilotis pencillata, Gould.

"White-plumed Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 43.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 244.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883); North, Cat. Nests and Eggs, Australian Mus., p. 205 (1889).

Geographical Distribution.—South Queensland, New South Wales, Victoria, South (includes the interior) and West Australia.

Nest.—Cup-shaped, small, sides slightly swollen; constructed of grass matted with spider's web and cottony substances, sometimes with greenish-coloured cocoons; inside lined with cottony material and long horsehair; usually situated well out of reach, suspended to the pendulous branch of a Eucalypt, not unfrequently near or overhanging water, but occasionally placed low in a Melaleuca, Acacia, &c. Dimensions over all 2–2½ inches by 2–2½ inches in depth; egg cavity 2¼ inches across by 1½ inches deep.

Eggs.—Clutch 2-3; long oval, compressed towards one end; texture fine; surface very slightly glossy; colour, delicate pinkish-white, moderately marked with distinct roundish spots of pinkish-brown and purplish-grey. Sometimes, especially more inland, the ground colour is pure white and the markings few and faint. Dimensions of a clutch in parts of an inch: (1) ·86 x ·59; (2) ·84 x ·58; (3) ·83 x ·58.

Observations.—The principal habitat of this familiar Honey-eater may, roughly speaking, be said to be the south. However, it has been observed in Central Australia and a portion of the west, notably between Lake Way and Lake Augusta, where Mr. G. A. Keartland states he observed the birds numerous wherever water was found. Several nests containing young were noticed

as early as 3rd July (1896), while at the camel depôt on an unnamed creek several clutches of eggs were secured during the following month.

The bird is common in Victoria, where it appears to be one of the few native birds that thrive, or, at all events, is not driven back by the advance of civilisation; in fact, its numbers have rather increased in the parks and gardens in the vicinity of Melbourne. In our school-boy days we called the bird the "Greenie," on account of its olive-green plumage.

The White-plumed Honey-eater, like all the members of its genus, is an active little creature, and a trifle pugnacious. Single-handed, it easily knocks a sparrow on its back. Should a large bird or natural enemy appear this Honey-eater sets up a shrill, rapid, monotonous "pee-pee pee" alarm, which is immediately taken up by all the species in the neighbourhood. The Honey-eaters then congregate about where the intruder is perched, screech and scold it till it is fairly scared, and glad to depart.

Gould describes the nest of this species, but not the eggs, except that they were three in number. He quoted from a South Australian correspondent, who wrote:—"The *Ptilotis penicillata* builds in the Acacias close to my house at Collingrove, near Angaston. I can sit at dinner and watch the young ones being fed. One female sat hatching close to the window, with the strong light of a moderator lamp shining on her at night."

A nest of the White-plumed Honey-eater containing a set of beautiful fleshy-white eggs, with pronounced spots of pinkish brown, are indeed, although common, amongst the most beautiful things of a collector's cabinet.

On the Murray I have found the eggs of the White-plumed Honey-eater almost white, and with very few markings. Still further afield, in Central Australia, Mr. G. A. Keartland, in the Report of the Horn Scientific Expedition, states he also took eggs of this species which were white, with faint spots.

Only on one occasion have I found the large flesh-coloured egg of the Pallid Cuckoo (*C. pallidus*) in a nest of the White-plumed Honey-eater.

The principal breeding months are September to December. However, the extreme limits of the season may be taken from June or July to February.

PTILOTIS ORNATA, Gould.

"Yellow-plumed Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 39.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 244.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848); also, Hdbk., vol. i, p. 515 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 204 (1889).

Geographical Distribution.—Victoria, (probably the south-west interior of New South Wales), South and West Australia.

Nest.—Cup-shaped, neat, small; constructed lightly of fine greenish grass, matted or intermixed with spiders' cocoons and wool; no particular lining inside except a few downy seeds, &c., on the bottom; usually suspended on a parasitical climber, bush, or small tree. Dimensions over all, $2\frac{1}{2}$ inches x $1\frac{5}{8}$ inches in depth; egg cavity, $1\frac{3}{4}$ inches across x $1\frac{3}{8}$ inches deep.

Eggs.—Clutch, 2–3; oval, compressed towards one end; texture fine; surface, faint trace of gloss; colour, beautiful, being rich salmon pink, distinctly blotched and spotted, particularly about the apex, with rich pinkish-brown and dull grey markings. Dimensions of a clutch, in parts of an inch—(1) ·82 x ·61; (2) ·82 x ·61; (3) ·81 x ·6.

The eggs, like those of the Little Yellow-spotted Honey-eater (*P. gracilis*) of Northern Queensland, are amongst the most richly-coloured of the Ptilotes.

Observations.—This very elegant and attractive Honey-eater, or, as Gould well named it, the Graceful, has a fair range of habitat over the drier and more inland provinces from Victoria to Western Australia, and possibly including New South Wales adjacent to the River Murray, or the Murray belts where Gould procured his birds.

I first met this graceful bird in the season of 1880 among a forest of saplings near Bagshot, Bendigo, where one or two nests were found suspended in a parasitical creeper (*Cassytha*) supported by small trees—a very secure situation for a small nest. But the most beautifully-situated nest I ever found of this species, and one well worthy of such a pretty bird, was in the Mallee country, suspended in a low Acacia bush, adorned with its golden store of "wee furry balls."

Again, 25th November, 1889, I met this Honey-eater in Western Australia, on the coast at Woodman Point, about 8 miles from Fremantle. There in a splendid shining clump of Eucalypts, the species of which I did not learn, a boy pointed out to me a nest suspended in a swaying branch. The late Mr. Roby Woods, in whose company I was, drove the buggy underneath; standing upon the seat I easily secured the nest, which contained one egg, while the pretty birds protested fearlessly, showing to perfection their graceful figures and lengthened yellow plumes upon their necks. I also noticed the same kind of birds flitting about the gum-trees in the town of Fremantle, where they seemed quite at home, as much so as its White-plumed compeer does in the gardens about Melbourne.

Breeding months, August or September to December.

Ptilotis plumula, Gould.
"Yellow-fronted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 40.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 245.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. I, p. 516 (1865); Diggles, Companion Gould's Hdbk. (1877.)

Geographical Distribution.—Northern Territory, North (probably) and South Queensland, South and West Australia.

Nest.—Cup-shaped, small, elegant; formed of dried grasses, lined with soft cotton-like buds of flowers, and suspended from a slender branch, frequently so close to the ground as to be reached by hand (Gould).

Eggs.—Clutch, 2 (and probably 3); salmon colour, with a zone of a deeper tint at the larger end, and the whole freckled with minute spots of a still darker hue; ten lines (·83 inch) long by seven lines (·58 inch) broad (Gould).

Observations.—The range of the Yellow-fronted Honey-eater extends more northerly than its close ally the Yellow-plumed, both in east and west Australia. I do not recollect seeing the bird in Victoria. All the specimens collected by Gilbert were from the York District, in Western Australia, where it inhabits the White-gum forests, breeding from October to January.

Ptilotis flavescens, Gould.
"Yellow Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 41.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 245.

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland, also New Guinea.

Nest and Eggs.—Unknown.

Observations.—Little is known of the habits and economy of the beautiful Yellow Honey-eater, which is a denizen of northern parts.

Mr. G. A. Keartland, of the Calvert Exploration Expedition, when on the Fitzroy River, with regard to this beautiful Honey-eater, noted :—"During the warm days of December and January these birds came to the water-trough in such numbers to drink and bathe as to completely line the trough. They seem to be exactly similar in habits to the *P. penicillata* (White-plumed Honey-eater), spending their time bathing, chasing each other, and seeking insects or pollen from the blossom amongst the Eucalypt foliage. The sexes are alike in plumage, and can only be distinguished by dissection. They were just building their nests when we left the locality, in March."

Ptilotis germana, Ramsay, is a sub-species of the Yellow Honey-eater. *Vide* "Catalogue Birds, British Museum," vol. ix, p. 246.

Ptilotis flava, Gould.

"Yellow-tinted Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 42.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 246.

Previous Descriptions of Eggs.—Campbell, Victorian Naturalist (1886); North, Cat. Nests and Eggs, Austn. Mus. App. (1890).

Geographical Distribution.—Northern Territory and North Queensland.

Nest.—Cup-shaped, somewhat shallow; lightly constructed of shreds of bark and a little grass, matted together with yellowish-white spiders' cocoons; inside lined with light brownish-coloured bark; usually suspended in a low tree; not infrequently in orange or lemon trees in an orchard. Dimensions over all: $3\frac{1}{2}$ inches by 2 inches in depth; egg cavity, $2\frac{3}{4}$ inches across by $1\frac{1}{4}$ inches deep.

Eggs.—Clutch 2; long oval, compressed towards one end; texture, fine; surface without gloss; colour, warm white marked, chiefly about the apex, with blotches of pinkish-red or pinkish-brown, and light purplish-brown. The same character of colouring as is generally found on eggs of the *Maluri* (Wrens). Dimensions of a clutch in parts of an inch: (1) ·91 x ·62; (2) ·86 x ·61.

Observations.—The beautiful Yellow-tinted Honey-eater is restricted to the coastal region of Northern Queensland, including the Gulf of Carpentaria.

As the orange and lemon trees were flowering in the orchard —a somewhat neglected one—adjoining our Cardwell camp, we had ample opportunities to observe many graceful Honey-eaters which were attracted thither by the seductive nectar of the flowers. No doubt many insects were devoured as well as honey. At times, especially during the morning, the garden was transformed into a perfect aviary by the presence of five or six kinds of honey-eaters flitting together about the blossom-laden trees, the little Brown with its cheerful song, the Dusky Brown-backed, the Yellow-spotted, and the Yellow. Perhaps the most prominent visitor for song and activity was the lovely Yellow Honey-eater. The memory of our camp would be incomplete if not associated with the duets of loving pairs of these birds.

A nest was discovered building in one of the orange trees, but an accident befell it before it was completed. Subsequently, on the 22nd September (1885), in the Acacia Vale Nurseries (Messrs. Gulliver), Townsville, I found another nest containing a pair of eggs, also suspended in an orange tree, at a distance of about 4 or 5 feet from the ground. Further north, in the Bloomfield River district, Mr. Le Souëf noticed a nest containing young of this species in a Mango tree that was heavily laden with fruit, and growing alongside the verandah of a dwelling; date, October, 1896.

In the "Catalogue" of the Australian Museum we find it recorded that Mr. J. A. Boyd forwarded the nest and eggs of the Yellow Honey-eater which he found, 10th January, 1890, in his plantation, Herbert River. The nest was mostly composed of the hair-like fibre of the cocoanut palm, and was suspended by the rim to the thin leafy twigs of a Cumquat (orange) tree. Mr. Boyd also stated that all the nests he took were mostly composed of cocoanut fibre. Two nests were built in a species of *Ficus*, and were 18 feet from the ground; another was built in a Mango about 8 feet from the ground.

Breeding months, end of August or September to January.

Ptilotis unicolor, Gould.

"White-gaped Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 46.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 249.

Previous Description of Eggs.—Campbell, Victorian Naturalist (1886).

Geographical Distribution.—North-west Australia, Northern Territory and North Queensland, also New Guinea.

Nest.—Cup-shaped; composed of strips of light brownish-coloured bark, matted with yellowish or golden cocoons of spiders; inside lined with a good ply of exceedingly fine grass, with a few fine Casuarina needles on the bottom; usually suspended to a forked twig in the topmost branches of a leafy (small, or moderately-sized) tree near a stream. Dimensions over all, 3–4 inches by $2\frac{3}{4}$ inches in depth; egg cavity, $2–2\frac{1}{4}$ inches across by 2 inches deep.

Eggs.—Clutch 2; oval, compressed slightly towards one end; texture fine; surface, faint trace of gloss; colour, warm or delicate pinkish-white, with large blotches and spots of beautiful light pinkish and purplish-red, the markings being fairly distributed but more inclined to congregate around the upper quarter. Most resembles those of the Yellow Honey-eater (*P. flava*) type. Dimensions of a clutch in parts of an inch, (1) ·88 x ·65; (2) ·86 x ·64.

Observations.—This modest-coloured Honey eater is a denizen of the northern part of Australia. Gilbert discovered it in the Port Darwin district. The situations, where it was usually observed, were those adjacent to swampy thickets, where it was seen generally in pairs, and, exceedingly lively.

I have found the White-gaped Honey-eater as far south as Townsville, where I took birds, nests and eggs on Stuart Creek. The day following the discovery of the Yellow Honey-eater's nest (22 September, 1885), I discovered this other, which was also new. The nest was suspended by the rim to a forked twig of a thickly foliaged tree, and contained two eggs perfectly fresh. Previously

I had found a nest in the upper forked branches of a similar tree. This nest contained a pair of fully-fledged young, for which the parents were very solicitous, and gave me a good opportunity of identifying the species.

Breeding months, probably from August to January.

MELIORNIS AUSTRALASIANA, Shaw.

Crescent Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. IV, pl. 27.

Reference.—Cat. Bds. Brit. Mus., vol. IX, p. 252.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883). North Cat. Nests and Eggs, Austn. Mus., p. 195 (1889).

Geographical Distribution.—South Queensland, N. S. Wales, Victoria, South Australia, Tasmania, and intermediate islands in Bass Straits.

Nest.—Cup-shaped, deep with thick-built sides; composed of somewhat broad strips of (*Melaleuca*, &c.) bark, protected with a loose but goodly supply of twigs; firmly lined inside with fine grass, and on the bottom with fine reddish flowering stalks of moss; usually placed low in thick underscrub, in sword-grass, or in ferns, in forest. Dimensions over all, 4–5 inches by 3 inches in depth; egg cavity, $1\frac{3}{4}$ inches across by $1\frac{1}{2}$ inches deep.

Eggs.—Clutch 3; oval, slightly compressed towards one end; texture of shell fine; surface very slightly glossy; colour, delicate fleshy tint, darker on the apex, which is boldly spotted and marked, usually in the form of a belt, with rich pinkish-red or reddish-chestnut, and dull purplish-brown or grey. Dimensions in parts of an inch of a clutch taken in Tasmania, (1) ·79 x ·56; (2) ·78 x ·58. A set taken in Victoria are smaller in size, and beautiful for their delicate character and lovely markings, measure—(1) ·75 x 54; (2) ·73 x ·54; (3) ·72 x ·55.

Observations.—This splendid little Honey-eater dwells in the depths of forests, especially where the thick undergrowth grows in moist or swampy places, or in mountain water-courses. The bird has a range from South Queensland to Tasmania.

It seems a misnomer to call the bird Tasmanian, for although it is numerous on that island, it is by no means uncommon in favoured localities on the mainland. The black lunar-shaped mark down each side of the breast of the male naturally suggests "Crescent" or "Horse-shoe" as a more appropriate and at once distinctive name for this Honey-eater.

The female is, however, destitute of the horse-shoe markings, a fact in favour of separating the species, as it was formerly, under the genus *Lichmera*, from the *Meliornes*, which have the sexes alike in plumage.

The first nest I found of the Crescent Honey-eater was in 1879 in dense Ti-tree scrub that marked the course of Scotchman's Creek, near Oakleigh. Unfortunately it contained young. Guided by the cue for time and place, the following season (in September), almost in the exact spot, I found another nest, prettily situated a foot or two from the ground in a bunch of graceful coral fern *(Gleichenia)* that was supported by the scrub, containing a richly coloured clutch of three eggs.

Writing from Tasmania, Mr. A. E. Brent says: "We rarely come across more than three eggs to a nest of this little bird, but I on one occasion took four eggs from a nest in the head of bracken ferns at Austin's Ferry, November, 1885."

Breeding months, August to December.

MELIORNIS NOVÆ-HOLLANDIÆ, Latham.

"Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 23.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 253.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. 1, p. 487 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 191 (1889).

Geographical Distribution.—South Queensland, N. S. Wales, Victoria, South Australia, Tasmania, and intermediate islands in Bass Straits.

Nest.—Cup shaped, sides somewhat thick; composed outwardly of twigs, bark, and grass; lined well inside, especially on the bottom, with particles of the brown velvety inner particles of Banksia cones, or soft seed-vessels of certain plants (an example from the Upper Werribee is lined entirely with beautiful soft yellowish-white seed-casings of a particular shrub); usually placed in a small fork, or among the upright twigs of a low thick bush, or in scrub. Dimensions over all, 3–4 inches by $2\frac{1}{2}$–$3\frac{1}{2}$ inches in depth; egg cavity, 2–$2\frac{1}{4}$ inches across by $1\frac{1}{4}$–$1\frac{1}{2}$ inches deep.

Eggs.—Clutch, 2–3, rarely 4; oval in shape, slightly compressed towards one end; texture of shell fine; surface without gloss; colour, pinkish-buff, with a darker hue around the apex, where is a belt of rich reddish-chestnut spots, intermingled with a few dull brown ones. Dimensions of a clutch in parts of an inch: (1) ·82 x ·62; (2) ·8 x ·62.

Observations.—Gould's initial genus of the numerous family of Australian Honey-eaters is peculiar to the southern parts of the continent. On account of their great love for Banksia trees they might have been fitly called Banksian-birds.

The species under notice, commonly called the New Holland Honey-eater, has its focus of numbers in Victoria and Tasmania,

including islands in Bass Straits, the birds thinning out to South Australia on the one hand and up to Southern Queensland on the other.

The coastal scrubs of *Leptospermum* (Ti-tree) interspersed with Banksias are the delight of the familiar New Holland, where its loud, shrill, and scolding note is always heard. It regales itself on the nectar of the flowering cones or "honey-suckles" as they were first called of the Banksias, while through half the year individuals may be found nesting in the warm Ti-tree scrub.

These interesting birds may frequently be seen airing their golden-edged wings in the private gardens of Toorak, as well as in more public domains near Melbourne. It is also pleasing to observe this attractive bird in the dry and arid Mallee tracts when that scrub is intersected with belts of dwarf *Melaleuca* (Ti-tree) bearing puce-coloured flowers. In such country I found two nests with a pair of eggs each during October, 1884.

The principal breeding months are from August to December or January, but individuals occasionally lay much earlier in the season, as the following dates prove:—On the 24th May, 1885, my friend and sportsman, Mr. J. F. Bradly, while shooting at Mordialloc, observed a nest of a New Holland Honey-eater containing two fresh eggs; while Mr. Scott, on 1st July, 1884, saw a nest with young birds.

I well recollect the first nest of this species I chanced to find. It was situated in a thick bush near Brighton, November, 1880.

It is interesting to note the variation of materials used in nest-lining in different localities. The Mallee nests were lined with rabbit fur and soft grass-seeds. Another nest from the Upper Werribee was furnished entirely with small calyxes of soft yellowish-white flowers belonging to some shrub.

I have never found more than three eggs or young in a nest of this Honey-eater, but Mr. A. E. Brent informs me he has occasionally found four to a clutch in Tasmania.

I have observed the egg of the Narrow-billed Brown-cuckoo in the New Holland Honey-eater's nest. The honey-eater is also a foster parent of the Pallid Cuckoo.

MELIORNIS LONGIROSTRIS, Gould.

"Long-billed Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 24.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 254.

Previous Descriptions of Eggs.—Gould, Bds. of Australia (1848); also Hdbk., vol. i, p. 489 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 192 (1889).

Geographical Distribution.—South and West Australia.

Nest.—Cup-shaped; somewhat rough outwardly, but thoroughly constructed of fine twigs, strips of bark, leaves, &c.; in some instances nearly all dry grass; inside of variegated appearance lined with Zamia (*Cycad*) wool and downy substance from Banksia cones, sometimes soft leaves or a feather are added, in other instances silky seed-vessels or Clematis-down are used chiefly; usually situated low in the centre of bushes. Dimensions over all, $3\frac{3}{4}$ inches by $2\frac{3}{4}$ inches in depth; egg cavity, 2 inches across by $1\frac{1}{2}$ inch deep.

Eggs.—Clutch, 2 usually, sometimes 3; oval, slightly compressed towards one end; texture of shell fine; surface without gloss; colour, pale or delicate buff, spotted, and sometimes blotched with reddish-chestnut, the markings being more around the apex. Dimensions of a clutch in parts of an inch: (1) ·82 x ·61; (2) ·79 x ·6.

Observations.—The Long-billed Honey-eater is the beautiful western variety of the familiar New Holland Honey-eater. It has been found as far east as Encounter Bay (S.A.). Dr. Ramsay, in his "List of Australian Birds," assigns the bird to the New South Wales and Wide Bay District columns, and makes the bird a sub-species. No doubt the New Holland Honey-eater and the Long-billed are very closely allied; but to see the respective birds at home, as I have enjoyed doing, there appear characteristic differences even in their voices, not to mention the specific distinction of the longer bill of the western bird.

In the recesses of the western forests I found many nests and eggs which agree with Gilbert's original description of those of the bird, which is locally called, the "Yellow-wing." The birds are numerous and frisky about the under scrub, chirping like chickens, or perhaps may be seen turning somersaults from some swaying bough after insect prey. The nests are usually placed a foot or two from the ground in a thick, low, bush, such as an Acacia. The birds sat closely, in many instances letting me almost place my hand upon them. Sometimes at my approach a pretty bird settling well down in its nest would ominously watch me with its pearly-white eyes.

Breeding season, July to December, the principal months being the last three.

MELIORNIS SERICEA, Gould.

"White-cheeked Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 25.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 254.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883). North, Cat. Nests and Eggs, Austn. Mus. p. 193 (1889).

Geographical Distribution.—Queensland, New South Wales, and Victoria.

Nest.—Cup-shaped ; outwardly composed of fine twigs, strips of bark and fine grasses ; lined inside with nests of spiders, and the soft downy substance of Banksia cones ; another example in the Australian Museum is almost entirely composed of strips of bark, with a lining of dried portions of Flannel flower (*Actinotus*). Dimensions over all, $3\frac{1}{4}$ inches by 3 inches in depth ; egg cavity, 2 inches across by $1\frac{3}{8}$ inches deep (North).

Eggs.—Clutch, 2 usually ; somewhat lengthened and pointed (at one end) in form ; texture of shell fine ; surface without gloss ; colour, pale buff or flesh tint, darker on the apex, which is surrounded with pinkish-red or reddish-brown spots. Dimensions of a smallish clutch in parts of an inch : (1) ·78 x ·55 ; (2) ·72 x ·54.

Observations.—This showy Honey-eater, with white cheeks, is an inhabitant of the eastern coastal country. The bird, Gould states, differs materially in its habits and disposition from the New Holland Honey-eater, being less exclusively confined to the scrub, and affecting localities of a more open character. He found it tolerably abundant in the Illawarra district, particularly among the shrubs surrounding the open glades of the forest. It is also common at Botany Bay and most parts of that coast. Gould did not meet with the bird during his excursions inland, nor did he succeed in finding its nest.

The eggs of the White-cheeked Honey-eater in my collection, which I described (1883) on the authority of Dr. A. E. Cox, were taken in Sutton Forest, Illawarra.

Mr. North informs us that the nest of the White-cheeked Honey-eater is usually placed in the fork of a Banksia or Hakea, partly resting with the rim of the nest attached to the branches holding it in position, but it is often found in orange trees in gardens, in which case the nest is always suspended by the rim.

Breeding season, June to November, and probably later.

Meliornis mystacalis, Gould.

"Moustached Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 26.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 255.

Previous Description of Eggs.—Gould, Bds. of Australia (1848), also Hdbk., vol. i, p. 492 (1865).

Geographical Distribution.—West Australia.

Nest.—Formed of small dried sticks, grass, and narrow strips of soft bark ; usually lined with Zamia wool ; but in those parts of the country where that plant is not found, the soft buds of flowers or the hairy flowering parts of grasses form the lining material, and in the neighbourhood of sheep-walks wool collected from the

scrub; usually placed near the top of a small, weak, thinly-branched bush of about 2 or 3 feet in height, in a scrub of sapling Eucalypts, &c. (Gilbert–Gould). Dimensions over all, 3 inches by 3 inches in depth; egg cavity, 2 inches across by 1½ inch deep.

Eggs.—Clutch, 2 usually; moderately lengthened in form; texture of shell fine; surface without gloss; colour, pale buff, darker on the apex, around which is a belt of fine spots of reddish-chestnut intermingled with purplish-grey ones, spots also appear here and there over the shell. Dimensions of a clutch in parts of an inch: (1) ·84 x ·6; (2) ·78 x ·59.

Observations.—The Moustached Honey-eater is an inhabitant of Western Australia, where, as Gould states, it beautifully represents the White-cheeked Honey-eater of the eastern coast.

The Moustached Honey-eater is fairly abundant in the scrubs about Perth Waters, and especially on the scrubby limestone hills in the vicinity of Fremantle. In both these localities I observed the birds which were remarkably shy compared with their Long-billed brethren of the Cape Leeuwin forests. I also discovered a nest building but did not obtain the eggs. The nest was constructed of *Melaleuca* (Ti-tree) bark, rimmed with fine dead twigs and lined with soft portions of Banksia cones (two varieties) and other soft seeds. However, eggs taken by a young local acquaintance the following season (8 Oct., 1890) reached me safely.

Gilbert found this species an early breeder, young birds ready to leave the nest having been seen on the 8th August. The time when I observed the nest building was towards the end of November. Therefore, we may infer that the breeding season is from the end of June or the beginning of July to December.

Manorhina melanophrys, Latham.

"Bell Minah."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 80.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 259.

Previous Discriptions of Eggs.—Campbell, Southern Science Record (1883). North, Cat. Nests and Eggs, Austn. Mus., p. 231 (1889).

Geographical Distribution.—South Queensland (Highfield), New South Wales, and Victoria.

Nest.—Cup-shaped, round, neat, but somewhat frail; composed of fine twigs partially covered outwardly with fine shreds of bark and cocoons, but sometimes entirely covered with moss and cocoons, occasionally ornamented round the rim with broad soft leaves; inside lined sparingly with rootlets and fine twigs, and on the bottom with downy seeds; usually fastened by the rim as if sewn by spider's web to the horizontal twigs of a bush or small

tree, sometimes attached to a bracken frond, in forest country. Dimensions over all, 3–4 inches by 2 inches in depth; egg cavity, $2\frac{1}{2}$ inches across by $1\frac{1}{2}$ inch deep.

Eggs.—Clutch 2, rarely 3; long, oval, compressed towards one end; texture fine; surface slightly glossy; beautiful rich flesh colour distinctly marked and spotted, more especially on the apex with rich chestnut or reddish-brown and dull purplish-brown. Dimensions of a clutch in parts of an inch: (1) ·95 x ·65 (2) ·9 x ·63.

Observations.—Capt. Grant, when in Western Port, Victoria, 1801, wrote:—"Among the birds noticed was the Bell-bird which has a note not unlike the tinkling of a bell, so that when a number of these birds are collected together, the noise they make is similar to that made by the bells of a team of horses."

> "Softer than slumber, and sweeter than singing,
> The notes of the bell-birds are running and ringing."—(*Kendall.*)

Some romance and sentiment have been attached to the Bell-bird which is a type of Honey-eater wearing an æsthetic yellowish-olive plumage, but has not the sprightly appearance of the Oreoica—the Bell-bird of the drier provinces of the interior.

Bell Minah is a good vernacular name, because the bird is closely connected with the *Myzanthæ;* moreover the name serves to distinguish it from the other Bell-bird. Yet the Bell Minah is lively enough in its actions, and is for ever examining in a most inquisitive manner and picking at the green gum foliage in search of food. A querist writes:—"The great curiosity of the Bell-bird to my idea is 'What does it feed upon?' It picks continuously at the back of the gum leaves in the same trees from year to year, and although I have crept to within a few yards of them when feeding on the Apple and Yellow-box scrub, and plucked the leaves afterwards and examined them, I could discover nothing. Perhaps it sucks a saccharine matter off the leaves, like Swainson's Lorikeet and the King Parrot do off the Stringybarks at certain seasons of the year. I should like someone who has studied the birds to kindly answer this."

The Bell Minah is very local, is gregarious to an extent, living in companies in certain restricted areas chiefly near water or humid swampy tracts in South Queensland, New South Wales, and Victoria.

In the early days of the colony of Victoria Bell-birds used to exist in the timber along the course of the Werribee River and on the Yarra above Hawthorn. The birds were never destroyed, yet they have mysteriously disappeared—probably removed to other forest retreats—notably to Gippsland, where from trees and scrub in certain favoured localities in summer or winter, in wet weather or dry, from sunrise to sunset, may be heard the incessant tinkling

voices of scores of birds. In no place I have ever visited are the Bell-birds more numerous than along the wooded slopes and dark gullies on the northern shores of Lake King.

On the subject of the departure of Bell-birds Mr. Issac Batey, of Sunbury, writing to *The Australasian*, states: "As regards birds that have left here one was the Bell-bird with its clear metallic ringing notes. This delightful little bird was very numerous on all the creeks years ago, and gradually dwindled away till there were only six of them left down the river, 9 miles from our house. This was in 1854 when those last of the Mohicans one day came flying up stream, and we boys remarked, 'It is good-bye to the Bell-birds,' a supposition that proved quite correct, as I have not seen a single one of them since on the whole length of Jackson's Creek." Mr. Batey was inclined to the belief that the coming of the Butcher-bird, which he said arrived from a westerly point about 1850, and was unknown in the district before, had something to do with the clearance of the Bell-birds.

We are aware that if the breeding grounds of birds are interfered with the birds will desert the place. So it is, I fancy, the case with the Bell-birds. They breed near the ground in low scrub and saplings underneath their particular food-trees. Therefore, when the country became stocked, cattle roamed and camped in these sequestered avenues, and so being disturbed the delightful birds departed.

At Metung, on Lake King, I was encamped for ten days or a fortnight when the majority of the Bell-birds appeared to have nested very early. In the middle of October, 1881, I found all the season's birds fully fledged and flying with their respective parents. I could not find a single nest containing eggs, although I found a great number of old nests, sometimes two or more in a bush. Any site seemed to be chosen for the nest, from scrub and bushes 12 feet high down to the common bracken fern. Some of the nests were the crudest and simplest of all Honey-eaters I am acquainted with, being constructed of just sufficient materials to ensure the safety of the eggs, and suspended by the rim to any convenient twig. The nests are sometimes patched and interwoven with portions of moss and lichen.

However, the same season Mr. R. A. Poole, who lived in the locality, secured for me several clutches of the second broods, also some of the early ones the following season, which were originally described before the Field Naturalists' Club of Victoria.

From some interesting observations on the Bell-bird sent to *The Australasian*, February, 1894, by a correspondent ("A.J.B.") at Metung, I extract the following:—"They make their nests usually in the fronds of the bracken fern, or in the low Dogwood scrub, making little attempt at concealment. I think the Bell-birds must lose a lot of their eggs and young ones through snakes,

as I have seen dozens of empty nests tilted over on the one side as though the snake had supported itself whilst helping itself to a delicate mouthful. During nesting-time the birds are bolder than ever, and will not hesitate to attack a dog if he ventures too near the youngsters. Several times when forcing my way through the scrub on hands and knees to try and see the Lyre-bird dancing on the mound, I have been defeated by getting too near their nests, as they at once set up their call, and in a few minutes dozens of them were flying around me, which was so good a hint to the Lyre-bird that it at once stopped its mimicking or whistling and made itself scarce."

Riding along the Murray frontage, near the Moira Lake, early (at sunrise) one April morning, I was agreeably surprised to hear from the living lines of gums that protected the river the voices of numerous Bell-birds. I hardly expected to find these birds so far inland, and I drew rein to listen to the chiming of the "ting-ting" notes that were piercing the crisp air of that delightful morn.

Then away in the sub-tropical parts of New South Wales, near the Tweed River, I have another pleasant reminiscence of Bell-birds. I recollect hearing their voices floating through a splendid forest of Ironbarks (Eucalypts) and Pines, where tree-orchids with clusters of yellowish flowers beamed from the trees as we passed in the coach, while the ground scrub around was rendered attractive by the presence of the stately figures of fern-trees, palms, and cycads.

The Darling Downs (Q.), is probably the most northerly habitat of the birds. Here I must give you Mr. Hermann Lau's own description taken from his MS. :—

"Bell-bird.—The outskirts of the so-called cedar scrubs have often favoured water tracts emerging either from the thickets or are kept in rocky enclosures. Here is where these interesting birds gather in numbers, sending forth their short, varied, bell-like notes, which tell the stray and thirsty wanderer that water is near.

* * * * * *

In clumps and circles of prickly shrub belonging to the Solanaceous family adapted much by the lichens, the Bell-bird resorts for nidification. Often have I found three nests in one little bush, advantage being taken of the lichens—the only material used for building purposes, except the lining, which is taken from a fibrous tree. The eggs are two, rarely three. Highfields, 22 miles north of Toowoomba, October, 1875."

There is, of course, a focus to the breeding season of the Bell-bird, probably August or September, but like many other honey-eaters some breed early, others late. Some years ago Dr. D'Ombrain took a Bell-bird's nest after Easter, while a relation of Dr.

Snowball took a pair of eggs the first week of May (? April), 1896, at Drouin, and shot the parent bird for his collection. The same season, in another part of Gippsland, a correspondent of Mr. C. French, jun., noticed young birds at the end of June.

On the other hand, Mr. Geo. H. Morton, who was enjoying his summer vacation at Gippsland Lakes, reported he had found a nest of the Bell-bird containing eggs, New Year's Day, 1889. Therefore, between these two extremes may be taken the breeding season of the Bell-bird.

MANORHINA GARRULA, Latham.

"Minah."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 76.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 260.

Previous descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 575 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 229 (1889).

Geographical Distribution.—South Queensland, N. S. Wales, Victoria, South Australia, and Tasmania.

Nest.—Cup-shaped; constructed of fine twigs and grasses or dead flowering-stalks of plants (herbs), or sometimes chiefly rootlets, occasionally ornamented with spiders' cocoons; inside lined with a ply of very fine grass, bark, or white cottony substances, sometimes hair, wool, &c., are added; usually situated amongst the thin forked branchlets of a low tree, sapling, or bush. Dimensions over all, 6–7 inches by 4 inches deep; egg cavity, 3½ inches across by 2½ inches deep.

Eggs.—Clutch, 3–4; oval, compressed towards one end; texture fine; surface slightly glossy; colour, warm white, mottled and spotted all over, more thickly on the apex, with rich reddish-chestnut and purplish-grey. Dimensions in inches of a pair taken in Tasmania: (1) 1·1 x ·79; (2) 1·1 x ·78. Of a fine clutch from the mainland: (1) 1·04 x ·78; (2) 1·04 x ·76; (3) 1·03 x ·78; (4) 1·02 x ·77.

Observations.—The familiar Minah, or, as it is called in some parts, the Soldier-bird, is one of the most common of our Honey-eaters. Wherever you meet the birds, whether near the coastal scrub, in belts of timber along a river, on a plain, or in the Mallee, by their scolding voices they at once make their presence known, and yours too, should you happen to be stalking upon rarer game. However common and annoying the birds may be, the shapely-built nest and reddish-coloured eggs are both very beautiful.

Two eggs I took from a nest near that grand natural sight—Corra Linn, Tasmania—were slightly larger than those generally taken in Victoria. This agrees with Gould's observations that the Minah in Tasmania is a more robust bird and larger in every respect than the same species found on the mainland.

General breeding months are from July or August to December; but it has been noticed in Queensland when some of the birds built early, in July or August, only one or a pair of eggs are laid as against a clutch of three or four laid when the season is more advanced and there is a great supply of food. Young Minahs have been seen in the nest on the Paroo, N.S.W., as late as April.

Mr. Lau discovered at Warroo (Q.), a "poor soldier" hanging dead, having been strangled with a long horsehair, which the bird had been evidently conveying to its nest.

This Minah's nest is sometimes the receptacle for the smaller, flesh-coloured egg of the Pallid Cuckoo (*Cuculus pallidus*). I have never been fortunate enough myself to discover the strange egg in the Minah's nest, but have seen several examples that were taken from such receptacles in the Ararat district.

The young of the garrulous Minah assume the adult colouring from the nest.

In 1891 Mr. C. F. Belcher, B.A., found a Minah's nest near the ground, built in long grass and bracken—a somewhat unusual site.

Manorhina obscura, Gould.

"Dusky Minah."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 77.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 260.

Previous Description of Eggs.—Gould, Bds. of Austr. (1848); also Hdbk., vol. i, p. 577 (1865).

Geographical Distribution.—South and West Australia.

Nest.—Cup shaped; composed chiefly of dead twigs, lined inside with soft grasses, feathers, &c., and usually situated amongst the topmost forked branchlets of small trees or saplings.

Eggs.—Clutch, 3–4; oval, compressed towards one end; texture fine; surface slightly glossy; colour, rich salmon, or rich reddish-buff, obscurely or softly marked with rich reddish-brown or chestnut and dull purplish-brown, forming a patch round the apex; resembles those of *M. flavigula*, both being altogether different from the eggs of *M. garrula*. Dimensions in inches: (1) 1·5 x ·75; (2) 1·04 x ·77.

Another pair taken near Broomhill, November, 1889, are somewhat round, exceedingly rich in colouring—one example, contrary to the rule, being darkest on the smaller end: (1) ·94 x ·74; (2) ·92 x ·74.

Observations.—I found this bird just as clamorous in the great western territory as the common species is in the eastern parts. The voices are almost identical in the two species, likewise the unmistakable struggling flight, and rapid motion of the wings, when the bird is flying from tree to tree.

MANORHINA FLAVIGULA, Gould.

"Yellow-throated Minah."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl.-79.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 261.

Previous Descriptions of Eggs.—Ramsay, P.L.S.N.S.W., vol. vii, p. 52 (1882). Campbell, Southern Science Record (1883).

Geographical Distribution.—Northern Territory, Queensland, N. S. Wales, Victoria, South, West, and North-west Australia.

Nest.—Cup-shaped; somewhat more compactly constructed than that of the more familiar Minah (*M. garrula*), and like the other species sometimes ornamented with spiders' cocoons; inside well-lined with soft, fibrous material, in some instances wool. Inside dimensions, according to Dr. Ramsay, are 3 inches by $2\frac{1}{4}$ inches deep.

Eggs.—Clutch, 3–4, occasionally 5; oval, compressed towards one end; texture, fine; surface, slightly glossy; colour, rich salmon or rich reddish-buff, minutely and obscurely spotted with reddish and purplish-brown, especially at the larger end. Dimensions in inches of odd examples, (1) 1·02 x ·77; (2) 1·0 x ·72.

Observations.—This smaller species may be said to be the great interior representative of the *Manorhinæ*. But outlying or isolated families of the Yellow-throated Minah are found in such localities as Darling Downs, Riverina, and the Lower Murray district. It has not the exceedingly noisy disposition of its larger cousins.

Mr. Lau observed on the Darling that the Yellow-throated Minah built higher than the common variety usually did, while Dr. Ramsay says in N. S. Wales the bird builds in trees and shrubs, frequently near the ground.

During the exploration of the North-west by the unfortunate Calvert party, Yellow-throated Minahs were frequently seen, and several shot between Lake Way and Separation Well. Isolated pairs were also noted in the sandhills of the desert until nearing the Fitzroy River. The late Mr. G. L. Jones, the youthful explorer—the first of the two lost ones to succumb to the burning desert—took a clutch of three eggs of this Minah during August (1896) a short distance north of Lake Augusta.

MANORHINA LUTEA, Gould.

"Yellow Minah."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 78.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 262.

Geographical Distribution.—North-west Australia and Northern Territory.

Nest and Eggs.—Unknown.

Observations.—Gould considers this to be the finest species of the genus, exceeding as it does every other, both in size and in the brilliancy of its colouring. Absolutely nothing is known of its economy.

ACANTHOCHÆRA CARUNCULATA, Latham.

"Red-wattled Bird."

Figure.—Gould, Bds. of Australia, fol., vol. iv., pl. 55.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 263.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848); also Hdbk., vol. i, p. 539 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 215 (1889).

Geographical Distribution.—South Queensland, N. S. Wales, Victoria, South and West Australia.

Nest.—Open, occasionally somewhat flat; composed of twigs and strips of bark matted together, in Western Australia, but in the east composed of twigs; lined with grasses or soft bark, wool, and a few feathers. Dimensions over all, 6–7 inches; egg cavity, 3½ inches across by 2 inches deep. Variously situated, from a low, open bush up to closely-set branchlets, or mistletoe clump of a tall tree.

Eggs.—Clutch, 2–3; nearly oval, compressed towards one end; texture fine; surface slightly glossy; colour, pinkish-buff or salmon-tint, blotched and spotted, especially around the apex, with rich reddish-brown, and dull purplish-grey. Dimensions of clutches in inches, eastern examples, (1) 1·26 x ·9; (2) 1·25 x ·92.

Examples from Western Australia are usually rounder in form, ground colour a lighter pinkish tone, and are smaller in size, (1) 1·16 x ·87; (2) 1·15 x ·86.

Observations.—The restless and shy Wattle-bird is found chiefly in the coastal regions, from South Queensland round to Western Australia, and is regarded as a common species. They are good eating—10 birds averaged 4½ oz. in weight. My first experience of the bird was many years ago, when I took its lovely, salmon-pink eggs in Albert Park, near Melbourne. Since I have taken their nests in such places as Mistletoe on Gum-trees in the Brighton and Oakleigh districts, in the open, prickly Bursaria bushes, in the Mallee, as well as in bushy trees in Western Australia.

In Mr. Lau's Queensland (South) note he says:—"I have seen the Wattle, or Gill-bird, near the Pacific, where Honeysuckles (Banksia) or sandy ground abound; nevertheless, as such trees are often abundantly to be seen towards the interior, this bird has found them out, and there is where I have met with nests, which were situated mostly on the top of a slender sapling. Nests formed of dry sticks, and rootlets inside; eggs, 2–3, mostly the latter number." My own experience in the south is that the eggs

are usually a pair, although I possess records of having taken two nests with each three eggs. I was able to verify Gilbert's cute observation, that the nests of the Wattle-bird in Western Australia were usually built without lining.

In the years 1853–60, I am told, Wattle-birds were very plentiful at Frenchmen's Amphitheatre, Warrnambool, and other places in the western district of Victoria, where seventy birds might be easily shot in a morning.

Mr. J. Sommers, Cheltenham, reported that he had found the single egg of the Pallid Cuckoo in a Wattle-bird's nest, 28–9–95.

The following "snake yarn" is a clipping from a Melbourne newspaper:—"Some years ago, while in Pyalong, my attention was attracted by the noise and fluttering of a Wattle-bird. I was surprised to see a snake up a Wattle-tree, in the act of swallowing a fully-feathered bird. His body was balanced on the limbs near the nest, which was 12 ft. or 13 ft. from the ground. The bird was slimed all over, and with great effort the snake was trying to gulp it down head first. I watched the process for some time, and then despatched the snake. The bird was dead. Near the log close by were some feathers (same sort), so I guess the reptile swallowed two birds. The snake was about 4ft. long; it had a thick neck, and was dark in colour."

The breeding months include August to December, but principally September and October.

Acanthochæra inauris, Gould.

"Yellow-wattled Bird."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 54.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 263.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. Hdbk., vol. i, p. 537 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 214 (1889).

Geographical Distribution.—Tasmania and King Island.

Nest.—Open, flat; composed of moderately-sized twigs and grasses; lined with wool or other soft material; usually situated in a low thick tree. Dimensions over all various, from 7 to 10 inches, depth about 3 inches.

Eggs.—Clutch, 2-3; lengthened in form; texture fine; surface glossy; colour, pinkish-buff or salmon-tint, moderately but boldly marked with blotches and spots of reddish-brown or chestnut and dull purplish-grey, the majority of the markings being on or about the apex. Dimensions in inches of odd examples—(1) 1·52 x ·98; (2) 1·4 x ·9.

Observations.—During three excursions to the different groups of islands in Bass Straits I noticed this fine large Honey-eater on King Island only; therefore, excepting that island, we may infer

that the larger Wattle-bird is found nowhere out of Tasmania. There is just a possibility that we may have missed it on Flinders—a large and scrubby island.

This Wattle-bird has a remarkable voice, which has been compared to that of a Blue Mountain Lorrikeet with a cold in its throat.

Mr. A. E. Brent writes: "On the Barren Plains, at the Great Lake, these birds build in hundreds; the trees are merely low bushes. I had ten days' nesting there in December, 1885 or 1886, and took several nests containing four eggs, also saw many containing four young birds."

The Wattle-birds are excellent eating, this species weighing $5\frac{1}{2}$ or 6 oz. each.

Breeding months, August to December.

ACANTHOCHÆRA MELLIVORA, Latham.

"Brush Wattle-bird."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 56.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 264.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848); also Hdbk., vol. i, p. 542 (1865). North, Cat. Nest and Eggs, Austn. Mus., p. 216 (1889).

Geographical Distribution.—North (?) and South Queensland, New South Wales, Victoria, South Australia, and Tasmania.

Nest.—Somewhat small, flat, in instances fairly built; composed of fine dead twigs; centre lined with small quantity of soft brownish strings of bark or other fibrous material; generally built in a closely-forked branch of bush or tree. Dimensions over all of a well-built nest 4–5 inches by 4 inches in depth; egg cavity 3 inches across by 2 inches deep.

Eggs.—Clutch, 1–2, in Tasmania occasionally 3; long or oval in form, slightly compressed towards one end; texture, fine; surface, slightly glossy; colour, pinkish-buff or salmon-tint, moderately blotched and spotted with reddish-brown or chestnut and dull purplish-grey, the markings being more numerous about the apex. Dimensions of single examples—(1) 1·16 x ·74; (2) 1·12 x ·73.

A pair from Tasmania are much darker and richer in the ground colour, and with markings larger and bolder. (1) 1·1 x ·78; (2) 1·07 x ·78.

Observations.—All round the eastern coast and in some portions of Tasmania, wherever the Banksias flourish there will be heard the harsh, guttural notes of the Brush Wattle. In such places as the shores of Lake King, Gippsland, and the park-like land near

Ararat, Victoria, I have seen these birds numerous. It was in the gullies running into the foot-hills of the Pyrenees that I secured the examples of eggs in my collection.

Gould mentions that two of the Brush Wattle-bird's nests and eggs, forming part of his great collection, were taken from the shrubs growing near the Botanical Gardens, Sydney, where these birds in those days were plentiful.

Breeding months, August or September to December.

ACANTHOCHÆRA LUNULATA, Gould.

"Little Wattle-bird."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 57.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 265.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848), also Hdbk., vol. i, p. 544 (1865).

Geographical Distribution.—West Australia.

Nest.—Slightly concave, and lightly constructed; composed of very fine twigs; centre lined with shreds of soft reddish-coloured bark, portions of grass, and one or two spiders' greenish-coloured cocoons. Dimensions over all—about 4 inches by 1½ inches in thickest part.

Eggs.—Clutch, 1 usually; long, oval, slightly compressed towards one end; texture, fine; surface, slightly glossy; colour, rich or dark pinkish-buff or salmon-tint, marked and spotted more numerously around the apex with rich reddish-brown and dull purplish-grey. Dimensions in inches of single examples—(1) 1·18 x ·8; (2) 1·17 x ·79.

Observations.—My first field-outing in Western Australia was to Middleton Harbour, part of King George's Sound. The locality was simply a repetition of some parts of the shores of Port Phillip—slightly undulating sandy ridges sustaining Banksias, Acacias, &c., between the beach, and Ti-tree (Melaleuca) swamps at the back—but the species of the vegetation was changed, likewise some of the birds, amongst which was the Lunulated Wattle-bird. It was the last day of September, 1889, and I found three nests in different stages—one building, one containing a beautiful egg, and the third occupied with a young one. All the nests were situated in thick, silky, or velvet bushes (*Adenanthos*). The week following, in the same locality, I took another nest with a fresh egg. Then on the west coast, towards the end of November, I obtained two more nests, each containing a single egg—one in the Karridale forest and the other at Coogee, near Fremantle. Incubation had commenced in both these instances.

The singular circumstances mentioned by Gilbert that the Lunulated Wattle-bird laid but one egg was proved in the five nests I found.

ACANTHOCHÆRA RUFIGULARIS, Gould.

"Spiny-cheeked Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 53.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 265.

Previous Descriptions of Eggs.—Gould, Bds. of Aust. (1848); also Hdbk., vol. I, p. 535 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 213 (1889).

Geographical Distribution.—South Queensland, New South Wales, Victoria, South and West Australia.

Nest.—Cup-shaped, strong, but thin, so thin that in some instances the contents may be seen from beneath; composed of long, round pieces of greenish grass, interwoven or matted with spider's web, some with the addition of a few cocoons; scantily lined on the inside bottom with wool and such like material, in some instances there is no particular lining; usually suspended by the rim in a bush—Acacia, &c.—or swaying branch of Casuarina or other low tree, in open forest. Dimensions over all, 4–5 inches by $2\frac{1}{2}$ inches in depth; egg cavity, $2\frac{3}{4}$–3 inches across by $1\frac{3}{4}$–2 inches deep.

Eggs.—Clutch, 2–3; oval, compressed and pointed at one end; texture, fine; surface, glossy; colour, light olive, moderately marked, but more thickly about the apex with umber and dull grey spots. Dimensions of a clutch in inches—(1) 1·06 x ·76; (2) 1·01 x ·74. Another pair—(1) 1·06 x ·72; (2) 1·05 x ·72.

These eggs are quite an exception to the usual character of colouring for Honey-eaters', and more resemble types of the Yellow-breasted Thickheads (*Pachycephalæ*).

Observations.—Probably no Australian Honey-eater is more interesting and pleasing than the elegant Spiny-cheeked. Its geographical range extends from Southern Queensland down south and across to Western Australia. It may be regarded as an inland species, but in winter it moves towards the seaboard, and is a visitor to the parks, cemeteries, &c., around Melbourne, Geelong, &c., where its peculiar gurgling call may be frequently heard.

The earliest I have heard the Spiny-cheeked Honey-eater about Melbourne (exact locality, Armadale), has been the 22nd May. The latest I have heard them being the 1st September, in the Botanical Gardens. About September these birds commence to return inland to their breeding haunts, which in some instances are not far away.

In October, 1882, I found two nests in the Mallee, near Nhill, Victoria. One was in an Acacia bush within reach. It was then building, the first egg being laid on the 20th, the second three days afterwards, when the nest was taken. The other nest was at a height of about 10 feet in an erect Casuarina (Bull-oak). It was also building. The first egg was deposited on the 18th, then an egg on each of the two following days. Full clutch, three.

Nearer home, on the Upper Werribee, November, 1890, with the Messrs. Brittlebank, I found two more Spinies' nests, as we called them. One was most charmingly situated in a wreath of feathery seeding Clematis that adorned a bushy Acacia, the other being situated in a shapely Native Cherry-tree (*Exocarpus*). Dates, 8th and 11th respectively.

The Messrs. Brittlebank have found the nests of the Spiny-cheeked Honey-eater in the following trees and shrubs, namely: Bursaria, Leptospermum, Dodonaea, Casuarina, Exocarpus, and in another tree that grows by the river bank which they forgot the botanical name of; also in Clematis and Loranthus.

Breeding months, end of September or beginning of October to December.

Entomyza cyanotis, Latham.

"Blue-faced Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 68.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 268.

Previous Descriptions of Eggs.—Gould, Bds. of Australia (1848); also Hdbk., vol. i, p. 562 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 223 (1889).

Geographical Distribution.—Queensland, New South Wales, Victoria, and South Australia.

Nest.—Cup-shaped, round, neat; composed of strips of bark, in some instances with grass; usually placed in a depression on the top or side of the deserted large-domed stick nest of the Chatterer or *Pomatostomus temporalis*. In some instances the nest is suspended in the ordinary Honey-eater-like fashion in the branchlets of a tree, and is substantially constructed of coarse strips of bark; lined inside with fine, reddish-brown (inner) bark, and a small quantity of grass. Dimensions over all of the latter kind of nest, about 6 inches by 4 inches in depth; egg cavity, about 3¾ inches across by 2 inches deep.

Eggs.—Clutch 2, rarely 3; oval, compressed towards one end; texture, fine; surface, slightly glossy; colour, pinkish-buff or delicate salmon-tint, boldly blotched and spotted about the apex with rich chestnut-brown and dull purple. Exactly resemble those of the Wattle-bird (*Acanthochæra carunculata*), and with the exception that the markings are usually less numerous, more confined to the larger end. Dimensions in inches of clutches—Taken in Victoria (1), 1·32 x ·9; (2) 1·23 x ·9. Taken in Riverina (1), 1·29 x ·86; (2) 1·24 x ·85.

Observations.—This large and splendid Honey-eater enjoys a goodly range, chiefly throughout the eastern half of Australia, and especially along the rivers of the interior.

It may be considered an inland species, and in Victoria it does not pass the Dividing Range—the southern limit of its habitat.

Gould, who says this attractive and beautiful Honey-eater is one of the finest of our indigenous *Meliphagidæ*, gives us a refreshing mental picture when he writes :—" I have frequently seen eight or ten of these bold and spirited birds on a single tree, displaying the most easy and elegant movements, clinging and hanging in every variety of positions, frequently at the extreme ends of the small, thickly-flowered branches, bending them down with their own weight. They may be easily distinguished from other birds with which they are frequently in company by their superior size, the brilliancy of their blue face, and the contrasted colours of their plumage."

I had an opportunity of proving the curious fact mentioned by Gould of the Blue faced Honey eater depositing its eggs in the deserted nest of the Chatterer (*Pomatostomus*). In the beginning of September, 1881, in the Bendigo district, I was wending my way along a track through timber—in fact, I had lost my road—when I observed a splendid Blue-face in a small tree. There was also an old *Pomatostomus* nest in the tree. I recollected Gould's remarks, and ascended to prospect. In the crown of the large stick nest I found embedded a round, open, bark-made nest, containing a large and lovely pair of the Honey-eater's eggs.

Gould further remarks, " that in places where no substitute is to be found, the Blue-face makes a nest like other species of its tribe."

On the 16th October, 1885, when at Coomooboolaroo, Queensland, with Mr. Harry Barnard, I had an opportunity of observing a nest suspended in a Eucalypt, which was owned, and apparently built by the Blue-faced Honey-eater, and from which we took a specimen of that bird's eggs. The nest resembled that of an Oriole, or Friar-bird, only was not so heavily constructed.

Mr. Harry Barnard's experience is that " In nine cases out of ten the Entomyza breeds in another bird's nest, mostly in old nests of *Pomatostomi* ; but the entrance is always enlarged, and the Entomyza builds its own nest inside, lining it with stems of dry grass, like the inside of a Friar-bird's nest.

"When the Entomyza builds its own nest independently, it very closely resembles that of a Friar-bird ; but is more loosely constructed. A pair once built close to our cow-shed, and obtained the material for it about the house. We had a quantity of rails (Lance-wood or Bastard Brigalow) about, which had the outside bark taken off. The birds pulled off the inner bark in strips for their nest."

Mr. Thos. R. McDougall, Claremont, (Q.) writes:—I have seen them (Entomyzas) breeding in the deserted nest of the Leatherhead ; have also seen them build a nest similar to that of the Leather-head (Friar-bird).

During a delightful excursion to the Lower Murray, beginning of November, 1892, Mr. J. Gabriel and I found a Blue-faced Honey-eater's nest in the topmost branches of a small Red-gum by the river. Our host, Mr. G. H. Morton, climbed the tree for the pair of eggs. After a consultation the three of us agreed that the nest had evidently been constructed by the bird itself. Mr. Morton, 3rd December, following year took another nest, apparently made by the Entomyza. Clutch, two eggs.

Mr. A. J. North, although he has not recorded having taken a nest of the Entomyza, says: "I have never heard of this bird constructing a nest itself, but relines the deserted tenements of *Myzantha garrula* (Minah) *Acanthochæra carunculata* (Wattle-bird), or a depression in the top of the dome-shaped nest of *Pomatostomus temporalis* (Chatterer)."

Here is the story of my venerable friend and acute field observer, Mr. Hermann Lau, respecting the Blue-faced Honey-eater, from the Dowling Downs (Q.): "It is one of our most handsome forest birds, and lively by nature. When other birds—The Soldier (*Minah*), Leatherhead, &c.—are building, this nest-robber either goes out foraging the material *to make its own nest*, gathering it from its neighbours, or puts itself in possession of their whole edifice—that is, supposing the neighbour is a weaker bird, and before the latter deposits its eggs. Once I witnessed a sight never to be forgotten. A Butcher-bird when returning with building stuff found an Entomyza deftly pulling away at its (the Butcher-bird's) property. The Butcher-bird drove off the other and kept it at bay, when to its horror the mate of the Entomyza arrived to help at the thievish work. Evidently a thought struck the Butcher-bird, so that it placed itself in the middle of the nest, which enabled that bird with its formidable beak to put both enemies to flight. Such is the habit of the Entomyza, the sequel being that its nest is like that of a Minah (*Myzantha*), in which 2-3 eggs are placed, and is hung fairly high. Two broods. September, 1874."

Breeding month, August to January, and sometimes, Mr. North states, as late as February.

Entomyza albipennis, Gould.

"White-quilled Honey-eater."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 69.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 269.

Geographical Distribution.—Northern Territory and North Queensland.

Nest and Eggs.—Unknown, but probably similar to those of *Entomyza cyanotis.*

Observations —The white at the basal of portions of the quills of the wings at once serves to distinguish this fine bird from its southern ally. Little is known of its economy except an interesting paragraph or two from Gilbert's observations in the Port Darwin district.

PHILEMON CORNICULATUS, Latham.

"Friar-bird."

Figure.—Gould, Bds. of Australia, fol., vol iv, pl. 58.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 271.

Previous Descriptions of Eggs.—Gould, Bds. of Austr. (1848); also Hdbk., vol. i, p. 547 (1865). North, Cat. Nests and Eggs, Austn. Mus., p. 217 (1889).

Geographical Distribution.—Queensland, New South Wales, Victoria, and South Australia.

Nest.—Large, open, deep, solidly built; composed of strips of stringy-bark, sometimes cocoons and string gathered near habitations are added; inside lined with a good supply of grass; usually suspended or stitched, as it were, by the rim to the forked branchlets of a pendulous limb of a Eucalypt, in forest or open forest country. Dimensions over all, 5–7 inches by 3–4 inches in depth; egg cavity, 4–5½ inches across by 2–2½ inches deep.

Eggs.—Clutch, 3 usually, but sometimes 4–5; oval, compressed towards one end; texture, fine; surface without gloss; colour, pale salmon or yellowish-buff, indistinctly marked with dull-chestnut, and dull-purplish spots, especially round the apex. Dimensions in inches of a pair taken in Victoria, (1) 1·3 x ·89; (2) 1·3 x ·88. Of a Queensland pair, (1) 1·22 x ·88; (2) 1·22 x ·86.

Observations.—This large, and remarkable Honey-eater, with its curious appearance and chattering calls, is not only well-known in collections, but likewise to all bush folk. It ranges over much of Australian forest and open country alike, west and north excepted.

Gould regarded the Friar-bird as a summer visitant to the more southern limit of its range. Probably he was correct, and that its visits are regulated by seasons, and the blossoming of various Eucalypts. One season (about 1870) these birds were in great numbers in the district of Springvale, Victoria, and no doubt in other localities contiguous. The forest everywhere resounded with their vocality. We shot as many birds for the table as our bags could conveniently hold. If a bird were wounded we soon learnt to be careful of its bill and powerful claws.

I shall always recollect my first Leather-head's nest, which I took as a boy. On the 9th November, of the season mentioned, we found a nest building, or about ready for eggs, in a medium-sized tree near Fern-tree Gully, at the base of the Dandenongs. A fortnight afterwards we walked from what is now Armadale to the

ranges and back in one day—45 miles—for the precious set of eggs. Of course we also found other species of eggs—Thickhead's, Fantail's, Robin's, &c.

We started about 4 o'clock a.m., when a waning moon and the bright morning star gave the eastern sky an additional charm. When we got beyond Malvern (Gardiner in those days), we overtook a spring-cart drawn by a restive colt. In the vehicle there sat a boy crying bitterly. In answer to our questions he said his father had got drunk or was locked up, and begged us to take him (the boy) home to Oakleigh. Taking compassion upon the lad (which also would give us a lift on our way), we saw all safely to the house, and placed the position of affairs before his mother. But just imagine our intense surprise, when, instead of receiving her gratitude for our little trouble, she scattered us with a stick, informing us that in future we had better mind our business. What subsequently happened to the poor boy, and to the "old man" when he returned home, was not left for me to record.

Gould states the Friar-bird commences breeding in November, when the birds become animated and fierce, readily attacking Hawks, Crows, and Magpies, or other larger birds that may venture within the precincts of the nest, never desisting from the attack until they are driven a considerable distance. So numerous did Gould find the Friar-bird breeding in the Apple-tree (*Angophora*) Flats, near Aberdeen and Yarrundi, on the Upper Hunter, New South Wales, that he remarks the birds might almost be termed gregarious.

I take the following interesting notes relating to the Friar-bird from Mr. Hermann Lau's MS. :—"Not gaudy in plumage, nevertheless of great interest. With it everything is odd. The tongue, unique in itself, expresses laughable articulations. The naked cowl-like head looks ridiculous. Impudent and daring, it steals material for its nest whenever a chance offers. The wool-shed of a station is very handy, where it finds twine and wool. It was at Yandilla (Q.) where I found a nest wholly constructed of these two articles. At another place (Warroo) the greater part of a nest was, I believe, about $\frac{1}{4}$ lb. of twine. This stuff the bird wound within and out and round the neighbouring branches, at the same time sewing it into a substantial grass nest padded with wool. Far from habitation, it takes for its nest the produce of land—dry grass—save now and then you will see a string or ribbon interwoven and dangling down. The Leatherhead is a bold orchard robber, and, approaching the site of its nest, it darts down like a Magpie, inflicting harm with bill and claws, whenever opportunity offers. I once killed such an infuriated bird with a stick. Breeds twice in a season, laying 3–5 eggs. Partly migratory. All over the Darling Downs. Nests generally in October."

Breeding months, end of September to December.

Philemon argenticeps, Gould.

"Silvery-crowned Friar-bird."

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 59.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 272.

Geographical Distribution.—North-west Australia, Northern Territory, and North Queensland.

Nest and Eggs.—Unknown.

Observations.—As Gould points out, the Silvery-crowned Friar-bird is somewhat inferior in size to the common species (*P. corniculatus*), from which it may also be distinguished by the crown of the head being adorned with well-defined, small, lanceolate feathers.

Philemon buceroides, Swainson.

"Helmeted Friar-bird."

Figure.—Gould, Bds. of Australia, fol. sup., pl. 44.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 272.

Previous Description of Eggs.—Campbell, Southern Science Record (1883).

Geographical Distribution.—Northern Territory and North Queensland.

Nest.—Open, bulky, somewhat loosely constructed ; composed of grass (including roots) and strips of Melaleuca bark interwoven, in our example is a rag and a piece of hay-band ; inside lined with long, pliable, dark-coloured twigs ; usually suspended in a fork at the extremity of a branch, in forest country. Dimensions over all : 8–9 inches by 7 inches in depth ; egg cavity, 5 inches across by 3 inches deep.

Eggs.—Clutch, 3-4, occasionally 5 ; lengthened in form, tapering towards one end ; texture fine ; surface slightly glossy ; colour, different from those of the other known species of the genus, being pinkish-white, boldly and beautifully blotched and splashed, especially on the larger end, with brownish-red and purple, the rest of the surface or intervening spaces being minutely dotted with the same colours. Dimensions of a clutch in inches : (1) 1·28 x ·87 ; (2) 1·26 x ·88 ; (3) 1·25 x ·88. Three from another clutch of five, taken on Magnetic Island, near Townsville, 1893, gives—(1) 1·24 x ·91 ; (2) 1·22 x ·91 ; (3) 1·2 x ·9.

Observations.—This fine bird is restricted, as far as is known, to Northern Queensland, including the Gulf of Carpentaria district, where it represents the ordinary Friar-bird of southern latitudes.

In 1893, in the Bloomfield River district, Mr. D. Le Souëf found the Helmeted Friar-bird numerous, where it commenced nest-building about the end of October. He was presented with a splendid nest by Mr. T. A. Gulliver, who obtained it from Magnetic Island, near Townsville. This example, together with three

eggs (there were originally five), found their way into my collection. The nest seemed to have been attached to mangroves.

Mr. Harry Barnard, while collecting at Cape York, found many nests with beautiful sets of eggs during the months of November, December, and January.

PHILEMON CITREOGULARIS, Gould.

Yellow-throated Friar-bird.

Figure.—Gould, Bds. of Australia, fol., vol. iv, pl. 60.

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 277.

Previous Descriptions of Eggs.—Campbell, Southern Science Record (1883). North, Cat. Nests and Eggs, Austn. Mus., p. 219 (1889).

Geographical Distribution.—Northern Territory (?), Queensland, New South Wales, Victoria, South and West Australia.

Nest.—Cup-shaped; loosely constructed; composed of grasses (dry and green), fine twigs, wool, cocoons, &c.; inside lined with fine, dry grass; usually suspended from a pendulous branch of a Eucalypt, sometimes near or overhanging water, in open forest. Dimensions over all, 5 inches by 6 inches in depth; egg cavity, 3 inches across by 2¾ inches deep.

Eggs.—Clutch, 3-4, one instance 5; nearly oval, slightly compressed towards one end; texture fine; slight trace of gloss on surface; colour, pinkish or purplish-buff, indistinctly smudged or blotched with umber, and chiefly light purplish-brown. Dimensions in inches of two from a clutch taken in Riverina: (1) 1·09 x ·77; (2) 1·07 x ·76. A clutch of three from Central Queensland are of a pinker coloured buff, and more distinctly blotched and spotted with chestnut or reddish-brown and purplish brown—(1) 1·1 x ·75; (2) 1·07 x ·76; (3) 1·05 x ·75.

Observations.—This smaller and plain-coloured Friar-bird is a dweller of almost the whole of the great interior tract of Australia suited to its habits, except, perhaps, west and north-west.

My introduction to this species was in November, 1877, at Wentworth, on the Darling River, where the birds, with chattering voices, were ravishing the bell-shaped flowers of imported trees (*Lagunaria*) that bordered the shrubs. On the Prince of Wales' Birthday, when a picnic of the towns-folk was being held up the river, having proceeded thither by steamboat, I found my "record" nest within reach in a bough overhanging the river-bed. The eggs, however, were much incubated. Another nest I found subsequently was placed in a low "Box" (Eucalypt) and contained a lovely fresh set of three richly coloured eggs.

From Mr. Hermann Lau's, MS., I take "Mocking-bird (*P. citreogularis*). It is not unlike the ordinary species with the exception of being smaller and having no protuberance over the

bill root. Its nest is more simply made from dry grass with rootlets for a lining. The site chosen for the cradle is the dense foliage of an Apple-tree (Eucalypt), not high up. The number of the eggs is always four. Found in open forest on the Darling Downs, Tummaville, October, 1868."

Breeding months, September to December.

PHILEMON SORDIDUS, Gould.

"Little Friar-bird."

Figure.—

Reference.—Cat. Bds. Brit. Mus., vol. ix, p. 277.

Previous Description of Eggs.—Ramsay, P.L.S.N.S.W., vol. vii, p. 52 (1882).

Geographical Distribution.—North-west Australia, Northern Territory, and Queensland (probably).

Nest.—Cup-shaped; constructed of bark and grass, suspended by the rim to the forked twigs at the end of some horizontal or drooping branch. In size about half that of the *P. corniculatus* or equal to that of *P. citreogularis* (Ramsay).

Eggs.—Clutch, 3–4; rich salmon-red, spotted with a darker tint, some of the spots fleecy, confluent, and distributed alike all over the surface of the shell, rather closer near the thicker end, but not forming a row there; in A a few confluent on the thick end forming a blotch on the top of the egg. In B the spots are more scattered and obsolete markings of pale lilac are disposed here and there over the surface. Length (A) 1·04 x 1·7 inch; (B) 1·05 x ·75 (Ramsay).

Observations.—This northern Friar-bird is very similar to the Yellow-throated, the more southern and interior species, but is smaller in all its measurements except the bill which is larger. In the neighbourhood of the Fitzroy River, North-west Australia, Mr. G. A. Keartland observed many of the nests of this Friar-bird, but only two eggs were obtained. The nests were usually made of coarse grass, cup-shaped, and were placed in the drooping foliage of a Eucalypt.

Dr. Ramsay gives the habitat as far south as the Dawson River district, and described the nest and eggs from the collection of the Messrs. Barnard of that locality, who, however, are not aware that that particular species is found in their neighbourhood.

PHILEMON OCCIDENTALIS, Ramsay.

"Western Friar-bird."

Figure.—

Reference.—Ramsay, P.L.S.N.S.W., vol. ii, 2nd series (1887).

Geographical Distribution.—North-west Australia.

Nest and Eggs.—Unknown.

Observations.—With regard to this doubtful species Dr. Ramsay says it is "similar to *P. sordidus*, juv., but having the sides of neck and chest tinged with citrous-yellow." Mr. G. A. Keartland, at Derby, North-west Australia, shot a bird answering this description. He says, "Whether another species or simply a variation in plumage I was unable to determine. It was being constantly attacked by the other Friar-birds which were numerous in the locality where it was shot."

No. 2.—NOTES AND OBSERVATIONS ON THE RANGE OF VISION IN SOME *ARANEIDÆ*.

By W. J. Rainbow, Entomologist to the Australian Museum.

(*Read Monday, January* 10, 1898.)

Although a great deal of time and study has been devoted by naturalists to working out the life-histories of the *Araneidae*, very little attention has been devoted to the question of range of vision. Among those who have treated upon the subject, the most noteworthy are Simon*, McCook†, Forel‡, Bingley§, Plateau‖, and Dr. and Mrs. Peckham¶. Of these writers, Simon, McCook, and Peckham agree in declaring that the *Citigradæ* and *Saltigradæ* are possessed of good powers of sight, while Forel and Plateau contend that their vision is very bad.

It is my intention, in the present paper, to give a résumé of a series of observations and experiments, made for the purpose of determining the distances at which objects are clearly discernible by some of our native species.

In studying the question of range of vision, it will be conceded by those who have given the life-history of spiders any attention or consideration, that the groups most likely to yield important results are those whose existence depends upon their activity; consequently, we are the most likely to find them among the *Laterigradæ*, *Citigradæ*, and *Saltigradæ*. None of these spiders fabricate snares for the capture of prey. The first of these groups, the

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* Histoire Naturelle des Araignées, Première Ed., p. 364.

† Spiders of the United States, p. 57 ; and American Spiders and their Spinning Work, vol. ii, p. 286.

‡ Sensations des Insects, Première Partie, Recueil Zoologique Suisse, T. iv, No. 1, p. 41.

§ Animal Biography, vol. iii, p. 455.

‖ Recherches Expérimentales sur la Vision chez les Arthropodes, Deuxième partie.

¶ The Sense of Sight in Spiders, Trans. Wisconsin Acad. Sci. Arts, and Letters, vol. x, pp. 231-249.

Laterigradæ, or "Crab" spiders, usually conceal themselves amongst herbage, the bark of trees, rocks, and walls, whence they sally forth to capture prey, a habit which would point to a tolerably long range of vision, but which was not satisfactorily established by experiment, although at close quarters their eyesight appeared to be very keen. For instance, prey placed at a distance of 3 inches from one of these spiders (*Stephanopsis altifrons*, Camb.) failed to attract attention; but, when the distance was reduced to ½ an inch, the insects were instantly seized. This was tried several times with unvarying results. Another experiment was that of tying a silk thread to a living but maimed insect, which was placed at about ¼ of an inch from the spider. Immediately the latter saw the insect it made a rush to seize it, but was compelled to make chase, the insect being pulled quickly away from it. An occasional jerk, made for the purpose of increasing the space between the spider and the insect, appeared to confuse the former, for it would stop and move, now to the right and then to the left, as though in search, and, failing to locate it, seemed disposed to give it up; but, upon the bait being placed, practically, "under its nose," resumed the chase. Such was the result of several experiments with *Stephanopsis altifrons*, Camb., and *Cymbacha saucia*, L. Koch, but I do not claim that as sufficient evidence in denoting the limit or extent of the range of vision in spiders of this group. It is interesting as far as it goes, but before the question can be settled with regard to the *Laterigradæ*, many experiments, spread over not only a wide collection of species, but also individuals, must be made before we can arrive at a definite conclusion.

That the *Citigradæ* possess a long range of vision has been proved by such eminent writers as Simon, McCook, and Peckham. McCook says, "He has seen a young *Dolomedes sexpunctatus* leap the side of a box and catch a fly on the wing, and return to its perch by the rebound of its drag-line. Such an act not only shows ability to see, but also some faculty to estimate distance, unless we suppose it to have been a chance shot." On the other hand, Felix Plateau says that "After experimenting with a small number (five) of species, that the sight of two large groups of spiders, the *Attidæ* and the *Lycosidæ*, is very bad, the limit of clear vision being about two centimeters." In their interesting paper on "The Sense of Sight in Spiders,"* Dr. and Mrs. Peckham give several quotations from Felix Plateau's papers on "The Sense of Sight in Arthropods,"† from which they conclude—and rightly so, I think—that his experiments "show not how far the spider can see distinctly, but at what distance it usually seizes its prey"; and they argue that "it is not safe to take for granted that if the spider does not try to catch the fly, he, therefore, does not see it.

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* Trans. Wisconsin Acad. of Sci., Arts, and Letters, vol. x.

† Recherches Expérimentales sur la Vision chez les Arthropodes, Deuxième partie.

As a mater of fact, spiders will often let flies—which certainly are as M. Forel has said, both stupid and imprudent—not only come within two centimeters of them, but climb upon them, and walk all over them, practically putting their heads into the lion's mouth, and yet will seem unconscious of their existence; perhaps they are not hungry." My observations, when in the field, have always impressed me with the idea that the *Citigradæ* were endowed with considerable length and keenness of vision, and the experiments I have made, with a considerable number of individuals of the genera *Lycosa* and *Dolomedes*, have certainly strengthened that view. On one occasion, when digging in my garden, I noticed a *Lycosa godeffroyi*, L. Koch, capture a beetle that was fully 3 inches away, and what made this feat the more remarkable was the fact that a small tuft of grass lay between it and its prey; likewise *Dolomedes neptunus*, Rainb., detected, at a considerable distance, prey that in colour bore a strong resemblance to the sea-wrack, amongst which it was hunting. These facts prove that M. Plateau, when he arrived at the conclusion that the vision of the *Lycosidæ* was "very bad," did so upon insufficient data. Nevertheless, one would not feel disposed to criticise an author upon solitary instances, such as I have detailed, were it not for the fact that others, equally as conclusive, have been noted. As far as my experience goes, I have always found that whether in captivity, or in the full enjoyment of liberty, the *Citigradæ* can, and do, see prey at a much greater distance than two centimeters.

For the purpose of testing the range of vision of these interesting creatures, I procured a box 15 inches long and 8 inches broad, and covered the bottom with paper that had been ruled off into inches. A specimen of *Lycosa godeffroyi* was then placed therein, and kept without food until the following day, when a beetle was introduced and placed at a distance of 6 inches from the spot whereon the spider was resting. For a few seconds the spider remained perfectly quiet, during which time the beetle had increased the distance by nearly an inch and a half. At length the Arachnid seemed aware of the presence of prey, and commenced to move towards it, slowly at first, but afterwards rapidly, and having secured it, conveyed it to a corner, where it devoured its meal. This experiment was repeated on several occasions and at varying distances, but the spider always made direct to the spot where the prey happened to be. By this means I was able to satisfy myself that *Lycosa godeffroyi* could see faintly at 8 inches, and distinctly at 5.

With *Dolomedes neptunus* I have made similar experiments, and with equally convincing results. Furthermore, rude imitations of insects never failed to attract, at a distance of 5 inches, when the spiders were hungry, proving, as has been asserted by Peckham, that these spiders are influenced, not by scent, but

by sight.* Similar experiments were made by Plateau, who states that the artificial insects upon being moved about were pursued, and in some cases seized by the spiders, just as in the case of the true fly. "But these facts," says Peckham, in combating Plateau's assertion, "do not argue that their vision is very poor, since in nature they must be constantly meeting with new forms of life upon which they may prey. Spiders eat a great variety of things: caterpillars, beetles, bugs, 'walking-sticks,' and in fact, all manner of insects, as well as other spiders."†

Now, in conducting experiments upon such subjects as the Athropoda, it is not only easy to make mistakes, but also to arrive at what appear to be hasty conclusions, because it is a difficult matter to decide upon a subject of which we can have little conception, and the sensations of these creatures is a case in point. This fact is clearly and logically demonstrated by Dr. and Mrs. Peckham‡ in their remarks upon the conclusions arrived at by MM. Plateau and Forel. The last named authors experimented with several Citigrade spiders by separating them from their cocoons, "and having noted their difficulty in finding them again, concluded that their sight was very poor and short." As a matter of fact these spiders, when so treated, do not rely upon, or even apply, the sense of sight when searching for their lost treasures. Those who have studied the habits of spiders know that the genus *Lycosa* carry their cocoons attached to the extremity of the abdomen, while those of the *Dolomedes* carry them with their falces. "It is indeed a well-established fact," as the Peckhams say, "that when the cocoon is taken away from one of these spiders, she is very much disturbed by its loss, and searches eagerly about for it, and yet she may run all around it without finding it, never recognising it unless she comes very close. This is the truth, but not quite the whole truth. As a matter of fact she never recognises it unless she touches it; but let her graze it ever so slightly with any part of her body and she instantly seizes it and reattaches it to her abdomen.

"The action is so sudden and rapid that one may easily make the mistake of supposing that the spider, in coming very near, recognises the cocoon through the sense of sight, but close attention will prove that this is never the case. She always comes into actual contact with it before taking it. We feel very confident that when the spider loses the cocoon she never looks for it, but feels after it. This is not so strange as at first appears, for it is quite possible that the spider constructs the egg-sac, deposits her eggs in it, closes the aperture, and attaches it to her body without ever seeing it."§ These remarks are followed by a record of a number

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* Trans. Wisconsin Acad. of Sci. Arts, and Letters, vol. x, p. 249.
† *Loc. cit.*, p. 235. ‡ *Loc. cit.*, p. 236. § *Loc. cit.*, pp. 236, 237.

of interesting experiments, which appear to fully prove the correctness of the authors' (Dr. and Mrs. Peckham) conclusion that the spiders only recognise their lost cocoons by the sense of touch. Several Citigrade spiders were experimented with, but one or two references will suffice. The cocoon was taken from a female of *Pirata minutus*, and "no matter how anxious she was to find her eggs, and no matter how close they were brought to her, she never recognised them except by touch."* For the next experiment, the cocoon of *Pirata montanus* was suspended at the end of a thread: "As the spider searched anxiously about, it was lowered until she could barely pass beneath without touching it. This arrangement required some manipulation, but we finally succeeded in suspending several cocoons at exactly the right height, and then watched the spiders as they passed and repassed without observing them. If, however, we allowed the cocoon to graze one of the posterior legs, the spider instantly turned and seized it. The position of the eyes of these spiders is such that unless they are totally blind they must have seen these suspended cocoons; but they are as dependent upon touch for recognising their eggs as thoroughbred bloodhounds are upon the sense of smell when hunting their game, or as English greyhounds upon sight."†

As far as my experience goes, I certainly agree with Peckham. *Lycosa godeffroyi*, L. Koch, and *L. tristicula*, L. Koch, when separated from their cocoons, never recognised them until they happened to touch them, and then they were eagerly seized, so that it would appear from these tests that Plateau and Forel formed a hasty conclusion when they said that the difficulty in finding their lost cocoons was evidence that the sight of the *Citigradæ* was "very poor and short." But if further evidence were needed, it is only necessary to point out that in two instances the cocoons of *Lycosa godeffroyi*, after being taken from the spider, were tinted a pale green and replaced in the experimenting-box. This fact alone would, one would think, be sufficient to deceive them—that is, if they depended upon the sense of sight to discover their lost treasures; but, nevertheless, directly one of the spiders touched its cocoon the latter was instantly seized.

It is only reasonable to assume that spiders, dependent upon dexterity and cunning for the capture of prey, must be endowed with a long range of vision; and this has been abundantly proved by Dr. and Mrs. Peckham in their extensive experiments with the *Attidæ*. These spiders, as Peckham says, lend themselves, by their natural habits, to more successful treatment under experiment than any other group, because, "when shut into a box which is supplied with light and air, they seem entirely unconscious of

* *Loc. cit.*, p. 237. † *Loc. cit.*, p. 237.

the fact that they are prisoners. They catch flies and devour them, sun themselves, mate, lay their eggs, and, indeed, carry on all the affairs of their daily life in the most natural and unconcerned manner imaginable, passing a whole summer in confinement with an appearance at least of perfect contentment." * Anyone who has watched the *Attidæ* when stalking prey cannot but conclude that they are possessed of a long range of vision. Probably one of the earliest references to range of vision in spiders is that found in Evelyn's "Travels in Italy." In that interesting work the writer gives the following lively narrative :—"Of all sorts of insects there is none has afforded me more divertisement than the *venatores* (hunters), which are a sort of *lupi* (wolves) that have their dens in rugged walls and crevices of our houses; a small brown and delicately-spotted kind of spiders, whose hind legs are longer than the rest. Such did I frequently observe at Rome, which, espying a fly at three or four yards' (!) distance, upon the balcony where I stood, would not make directly to her, but crawl under the rail, till, having arrived at the antipodes, it would steal up, seldom missing its aim ; but if it chanced to want anything of being opposite, would, at first peep, immediately slide down again till, taking better notice, it would come the next time exactly upon the fly's back ; but if this happened to be not within a competent leap, then would this insect move so softly, as the very shadow of the gnomen seemed not to be more imperceptible, unless the fly moved, and then would the spider move also in the same proportion, keeping that just time with her motion as if the same soul had animated both these little bodies ; and, whether it were forward, backwards, or to either side, without at all turning her body, like a well managed horse ; but, if the capricious fly took wing and pitched upon another place behind our huntress, then would the spider whirl its body so nimbly about as nothing could be imagined more swift, by which means she always kept the head towards her prey, though, to appearance, as immovable as if it had been a nail driven in the wood, till by that indiscernible progress, being arrived within the sphere of her reach, she made a fatal leap, swift as lightning, upon the fly, catching him in the pole, where she never quitted hold till her belly was full, and then carried the remainder home."

Writing upon the question of vision in the *Attidæ*, Dr. McCook says :—"Their rapid and marked change of manner when prey is sighted, the mode of approach, like the action of a cat creeping upon a bird, the peculiar behaviour displayed when the final spring is made, are not to be accounted for on any theory other than a keen sense of sight,"† and as this eminent naturalist has devoted many years to the study of these creatures, his view of the

* *Loc. cit.*, pp. 240, 241. † Spiders of the United States, p. 286.

question is not only entitled to respect, but must bear very great weight. The species possessing the longest range of vision with which I am acquainted are the beautiful *Attus volans*, Camb., and *A. splendidus*, Rainb. These spiders detected prey at a distance of 7 inches. The instant one of them saw an insect in the box in which it was imprisoned, it sprang upon it with unerring precision, proving not only that it saw it, but also that it had accurately gauged the distance. With other species with which I experimented, such as *Ergane scutulata*, L. Koch, the distance at which they detected prey was less, ranging from 5 to 3 inches. Whenever a fly was introduced, if the imprisoned spider was resting in a corner, it instantly displayed signs of activity and keeness of vision, for which ever way the fly moved, the Attid would follow its course by moving its cephalothorax either to the right or left, so as to keep its prey in view; when the fly stopped, the spider would commence to draw upon it with a slow, stealthy movement; if it moved, then the pace would be quickened, and so on until it had, unperceived by the fly, arrived within leaping distance, when the final spring was made.

CONCLUSION.

From a study of the foregoing evidence, therefore (leaving out of the question the experiments upon the *Laterigradæ*, which were not sufficient to be conclusive) I am compelled to support the decisions arrived at by Simon, McCook, and Dr. and Mrs. Peckham, that the *Citigradæ* and *Attidæ* are each endowed with long range of vision, and that this is the only theory that can be safely advanced in explanation of their habits either in the field, or in confinement.

No. 3.—TRANSPLANTATION OF THE RECURRENT LARYNGEAL NERVE.

By T. F. Macdonald, M.B., C.M.

(Read Tuesday, January 11, 1898.)

To appreciate the idea underlying the above experiment, the peculiar anatomical relations of the recurrent must be kept in mind. The nerve is a branch of the vagus given off in the thorax; on the left side it dips round the arch of the aorta, and runs back from thence to supply the crico-arytenoid muscle of the larnyx. This disposition of the left nerve round the aorta renders it peculiarly liable to injury as seen in cases of aneurism of the arch of that

vessel in man when loss of voice is a common symptom due to pressure of the aneurism upon the nerve producing paralysis of the muscles supplied by it.

This is the pathology of that disease in horses known as roaring; the crico-arytenoid muscle of the left side of the larnyx is paralysed, the paralysis being caused by injury to the recurrent nerve.

Such being the case, it struck me that if the nerve could be cut in the neck and replanted into the vagus, that not only would it be freed from further injury from the aorta, but that in cases of disease it might be regenerated and in turn regenerate the muscles at fault in roaring.

Having obtained a license from the Government to experiment upon donkeys, I carried out several experiments in this direction in the Royal Veterinary College, London. I had intended to do twelve cases of transplanting, but my first attempts were so completely successful as to preclude the necessity of further experiment.

Under chloroform the recurrent larnygeal and vagus nerves were exposed by dissection at the junction of the middle and upper third of the neck; the recurrent was then cut and looped through a slit made in the vagus with a scalpel; a catgut suture lightly now fixed the nerves together, and the wound in the neck was aseptically stitched and dressed.

Upon section of the nerve distinct roaring was immediately produced in the donkey, and this continued for about three weeks when improvement could be observed; the animal was then turned out near Hampstead and seen from time to time for eighteen months, the breathing became perfectly sound. It is, therefore, possible to transplant the recurrent nerve with impunity, and there are now no theoretical reasons at least why other nerves should not be dealt with in a similar manner. I have thought that in those cases of loss of voice in man from aneurism of the arch of the aorta that transplantation of the recurrent might be tried.

In conclusion, I may may say that up to the date of my experiments in this direction, physiologists held the firm opinion that nerve could not be transplanted, and, therefore, from a purely scientific point apart from its practical bearing upon veterinary surgery, the experiment thus described is not devoid of interest.

No. 4.—ON THE PHYSIOLOGY OF THE BRAIN OF MARSUPIALS.

By J. F. Flashman, M.D., Ch.M.

(Read Monday, January 10, 1898.)

No. 5.—THE DISTRIBUTION OF LIZARDS IN THE PACIFIC.

By A. H. S. Lucas, M.A., B. Sc.

(Read Monday, January 10, 1898.)

No. 6.—NOTES EXPLANATORY OF AN EXHIBIT OF SOME INTERESTING AUSTRALIAN FISHES, AND THE JAWS OF AN APPARENTLY UNDESCRIBED SHARK.

By J. Douglas Ogilby.

(Read Monday, January 10, 1898.)

No. 7.—ECONOMIC ORNITHOLOGY ILLUSTRATIONS.

Exhibited by A. J. North, C.M.Z.S.

(Tuesday, January 11, 1898.)

No. 8.—ON SOME POINTS OF INTEREST IN THE STRUCTURE OF CERTAIN COCCIDS.

By C. Fuller.

(Read Saturday, January 8, 1898.)

No. 9.—ON SIGHT- AND SMELL-FEEDING IN AUSTRALIAN FISHES.

By Gregg Wilson, M.A., D.Sc., Ph.D.

(*Read Monday, January* 10, 1898.)

No. 10.—NOTES ON EXHIBITS OF ENLARGED MODELS OF AUSTRALIAN PLANTS.

By R. T. Baker, F.L.S.

(*Read Monday, January* 10, 1898.)

No. 11.—NOTES ON THE HISTOLOGY OF PODOCARPUS.

By A. H. S. Lucas, M.A., B.Sc.

(*Read Monday, January* 10, 1898.)

No. 12.—NOTES EXPLANATORY OF AN EXHIBIT OF A FINELY PRESERVED SERIES OF SPECIMENS OF PERIPATUS AND LAND PLANARIANS.

By T. Steel, F.L.S.

(*Read Tuesday, January* 11, 1898.)

SECTION E.—GEOGRAPHY.

PRESIDENTIAL ADDRESS.

By Sir JAMES HECTOR, K.C.M.G., M.D., F.R.S.

(*Delivered Friday, January* 7, 1898.)

[*Abstract.*]

BEING unable to attempt any review of the great achievements in geographical exploration since the last meeting of this section, seeing that I have not had access to the extensive literature on the subject, I am glad to observe that the papers which are to be communicated to the section will review the most salient advances that have been made, of which I may indicate the following.

Since our last meeting the results of the exploring expeditions equipped by the munificence of the late Sir Thomas Elder and Mr. Horne have been made public, and the wonderful expansion of the knowledge of the central and western parts of the Australasian Continent, obtained through their intrepid journeys, will greatly assist the material development of the vastly rich but hitherto neglected interior area of Westralia.

Another feature of great prominence to the future advance of geographical discovery in the more difficult parts of the Australasian Continent is the steady extension of the "Artesian well" system into the arid areas of the interior, where the absence of a reliable water supply has not only prevented the settlement of the country but even its exploration, and has caused the loss of many enthusiastic and brave pioneers under circumstances of intense personal suffering. When the courses of underground water circulation are fully comprehended and utilised both exploration and occupation of large and almost unknown areas will become possible.

In New Zealand the additions to our geographical knowledge of most interest are chiefly those arising from the detailed exploration of the Alpine fastnesses of the higher mountain ranges and peaks. These explorations which are partly due to the Government surveyors, but also largely to the efforts of the New Zealand

Alpine Club, will, it is to be hoped, greatly increase the attractions of New Zealand for the more adventurous class of tourists.

The retouching of Victoria Land in the Antarctic by the s.s. "Antarctic," after the lapse of so many years since Ross's discovery, also deserves passing mention, as, though only a whaling venture, the expedition was largely guided and assisted by the Melbourne branch of the Geographical Society of Australia. The voyage of the "Antarctic" has been described in several articles by Capt. Kristensen and Mr. Borchgrevinck. The "Antarctic" was the first and only vessel with steam power that has yet visited Victoria Land, first discovered by Ross, in 1840. She had a very small steaming power, and was inefficiently equipped in many ways, so that the ease, celerity, and safety with which she penetrated so far south proves that an organised expedition with ample steam power should have no difficulty in making extensive explorations.

The phenomenal development of both political and physical geography in Africa has been very pronounced in late years, and modern civilisation is developing rapidly over the "Dark Continent." An extraordinary feature in its past geography is the suggestive discovery of forms of life having marine affinities in the great freshwater lakes that occupy the elevated interior plateau of Africa, 2,000 feet above the present sea level.

In Asia rapid and practical expansion of geography is in progress, not only by continued preliminary explorations in the austere regions of Northern Siberia, but also through the energetic development of a railway system through the extensive area of temperate country the nature of which has been little known hitherto; and further additions to our knowledge have also been made, it is sad to say, by the military expeditions which it has been found necessary to organise to invade the fastnesses of the great mountainous districts of Northern India.

On the American continent a great impetus has been given to fresh explorations by the discovery of the rich Klondyke Goldfield in the far north-west of Alaska, a region that has been considered hitherto as being too inhospitable and worthless to be worth attention. Its survey, which is now in progress by the Canadian Government, will be attended by enormous hardship and difficulties, as I can testify from personal experience; but the results will be gladly welcomed by geographers.

The physical surveys in other parts of America are being pushed forward vigorously, and the results of these by the United States Government are published with minute details, owing to a liberal munificence that is unequalled in other countries.

But the crowning event that has absorbed the interest of geographers since the last meeting of this section is the successful achievement of Nansen. With high courage and great prevision

Submarine Geography.

Adapted from the Reports of the "Challenger" Expedition.

Sir JAMES HECTOR, K.C.M.G., M.D., F.R.S.

he entered on what was at the time of its organisation considered by almost all who had experience of Arctic voyages to be a hopeless expedition. With faithful reliance on his theory, he permitted his strongly-built and specially well-equipped vessel the "Fram" to become embedded in the great Arctic ice mass, apparently with no chance of escape. But, as he had expected from his better knowledge, the ice carried his stout vessel in a definite direction, and, drifting over the Polar region, was freed from the ice-grasp after three years' imprisonment, with the whole party in excellent health. Nansen and his companion Johansen had left the "Fram" in the second year, and returned on foot and in kayaks, spending a whole dark winter of six months' night on the north end of Franz Joseph Land under circumstances of the greatest conceivable hardship. Yet they returned to civilisation almost on the same day as the "Fram." It is not necessary to dwell on the details of this attractive subject, which has so recently aroused such intense public interest. The scientific results of this wonderful venture have not yet been published, but two remarkable advances in geographical science have been announced:—1st. That the North Polar Ocean is not a shallow sea with scattered islands distributing icebergs, as has hitherto been supposed; but it is a profound ocean basin, which should hereafter be known as *Nansen's Basin.* So little had this condition been expected, that the "Fram" was not provided with deep sea sounding apparatus, and Nansen had to manufacture some from wire shrouds; and on frequent occasions, after boring through 37 feet of ice, obtained a depth of nearly 2,000 fathoms, or $2\frac{1}{4}$ miles, without touching bottom. 2nd. That there are definite movements of the great Polar ice-cake, and that they cross and do not merely circulate round the Pole. It is as if the ice in winter accumulated in greatest abundance along the Siberian border of the Polar Sea, and in summer progressed like a great melting and plastic glacier in the direction of Spitzbergen and Greenland, gravitating towards the warm currents close to the Gulf Stream, which, by melting the ice-border at that point, diminish the pressure. This brings me to the subject on which I wish specially to address the section.

SUBMARINE GEOGRAPHY.

Three quarters of the whole earth's surface is concealed from us by the oceans, which have an average depth of 3 miles, and an extreme depth, so far as known, of $5\frac{8}{10}$ miles, while its cubic contents exceed 400,000,000 cubic miles. The larger area of the sea bottom ranges from the shore line to 2 miles in depth.

For our knowledge of the ocean bed we are dependent on the sounding-line, and the improved appliances in connection with it which have been introduced within the last twenty years. The

earliest knowledge that we have does not extend back further than fifty years; but it was not till the "Challenger" expedition, only twenty years ago, that any thorough and extended accumulation of facts was made. Since then we have had the soundings in the North Pacific by the "Tuscarora" and the "Enterprise" (both American). And in the Atlantic and Indian seas, moreover, we have had numerous sectional soundings of the ocean bottom made in connection with the multitude of submarine cables, which have greatly added to the knowledge of the subject. But for fullness of detail in every particular that demonstrates the nature and physical character of the ocean at every depth, and the form and composition of the bed of the ocean, nothing has approached the results obtained by the scientific staff of the "Challenger," which have now been completely published in some fifty bulky quarto volumes.

As these are rarely accessible, I have availed myself of them, and particularly the last two volumes, which contain the masterly summary of my friend Dr. John Murray, who took up the work after the lamented death of Sir Wyville Thomson.

Yet, after all, our knowledge of the subject is still very slight and only provisional, seeing that the observations have been limited to irregular lines very sparsely distributed over the ocean according to the tracks of the exploring ships. Even a few miles north or south of their course, great features may exist which escaped notice.

The observations made at the different stations or points of deep water were, 1st, the depth; 2nd, the temperature at frequent intervals from the surface to the sea bottom, and also the chemical composition and specific gravity of the sea at all depths; 3rd, the nature of the material which formed the deposit at the bottom; 4th, the determination of the nature of the animal and vegetable life at every depth and at every distance from the nearest shore land.

The result of the investigation goes to show—

1. That surrounding all continents and the satellite islands a wide fringe or shelf has been formed by the spreading out of the detritus, resulting from the atmospheric denudation of the land and the erosion of the shore line by the sea waves. The coarse detritus, including the finest sand, rarely extends to 500 fathoms or half a mile in depth. The mean slope of the shore or terrigenous deposits is about 1 in 40, or about our steepest railway grade. There are exceptionally steep grades in some cases which are most probably due to the shelving shore formation having been eaten into by deep ocean currents, as for instance, west of Europe, when the shelf contour continues as a flat plateau, the depth of the water being only 600 feet 200 miles west of Lands End; it then descends with a slope of 1 in 12 to a depth of 12,000 feet, which is about the average depth of the great flat bottom of the

East Atlantic Basin. Some of the shoreward slopes round the isolated oceanic islands must be still steeper—for instance, the Bermudas and the solitary Island of St. Thomas in mid-Atlantic, rise high above the surface of the sea, while at no great distance we find that the depth of the ocean is 17,000 feet.

2. The next great feature of the ocean-bed is the existence of extensive submarine plains rising almost to the middle depth reached by the terrigenous deposits, but separated from them by deep, wide channels, and often having great basins or circumscribed depressions like submarine lakes on their surface. Occasionally these plains show evidence of having been caused by the subsidence of formerly existing land surfaces, but as a rule, the nature of the material of the sea bottom on these plateaux indicate only such deposits that settle from the ocean water far from land. They are, however, often traversed by steep ridges like submarine mountain chains, the peaks of which sometimes reaching almost to or above the sea level as oceanic islands, but in such cases the rocks are almost, without exception, of igneous origin and coral formations which indicate the influence of volcanic activity. The Pacific Archipelago presents a wonderful development of this character of the ocean bed. In every part of the sea bottom the deposit contains fragments of volcanic rock, especially pumice-stone, but these have been mostly derived from the slow sinking of particles that have fallen on the surface of the sea and been waterlogged while drifting along far from where they were dropped into the sea or washed out by the rivers from the land.

3. The great channels which form the deeper but not the most profound parts of the ocean floor. They lie between the land and the submarine plains, at an average depth of 3½ miles. They form a continuous reticulation all over the ocean bottom. If the ocean were gradually dried up until the shoreward shelf and the oceanic plains were exposed, the outline of the remaining ocean would somewhat resemble the form of the canals that have been observed to reticulate the surface of the planet Mars.

4. Further evaporation of the sea would disclose the existence of profound and abrupt depressions—termed "deeps" in the floor of the most profound parts of the ocean bed. Probably only a few of them have been discovered by the sounding-wire, but they present remarkable features. They are generally in close vicinity to greatly elevated land, or to land on which intense volcanic and seismic or earthquake activity is prevalent. The most remarkable of the great depressions is the Tuscarora Deep, parallel with the east coast of Japan; the Krümmel Deep, parallel with the west coast of South America; the Ross Deep, in the Antarctic regions; and the Penguin Deep, east of Kermadec Island, north-east of New Zealand, where the deepest sounding ever found was lately taken by H.M.S. "Penguin."

While the slopes or grades of the sea bottom in the basin and deep channels is very flat, the few measurements which have been made of the sides, one may almost say walls, of the profound abyssal deeps, show a very steep angle for subaqueous material to form a slope having even a slight degree of stability. The few observations made indicate that there exists a slope steeper than 1 in 20 from the 2-mile level of the surrounding ocean to a depth of $5\frac{1}{2}$ miles. These wonderful deeps have generally a lesser extension and are deeper than the height of the highest mountains, and it has been conjectured that they have a relation to the nearest great mountain range, with which, as it were, they are paired, the relation being like that of a model and its mould.

The causes of the inequalities in the form of the ocean bed are no doubt the same as those which have caused the great inequalities of the land surface, great swelling elevations producing plateaux ; slow-moving subsidence, producing troughs like the Caspian basin on land, and the larger submarine basins of the ocean.

The abyssal deeps of the ocean appear to mark areas of rupture and extreme faulting of the earth's crust analogous, but in the reverse direction, to the mighty upliftings and crushings which have produced our most mighty mountain chains of the class which have linear extension.

We can, therefore, safely conclude that the same onward moving waves in the earth's crust which lift up the continents and produce the mountains are at work also under the ocean. Some, however, hold that much of the deeper portion of the flat-bottomed ocean has never suffered emergence, having always been what are termed permanent ocean-beds. The chief argument for this assumption is, that material similar in chemical and mineral character to that which floors the great depths of the ocean has never been detected in any geological formation even of the highest antiquity. No student of geology can doubt the enormous changes which have taken place in very recent times on land, both by placid swelling and sinking, and also by what look at first sight as violent disruptions, but which are really movements and involvements due to small but frequently repeated movements in the upward or downward direction.

We thus arrive at the following inferences :—

1. That an extensive terrigenous shelf must indicate a long-continued period of stability, with only moderate oscillation of the contiguous continental shore line.

2. That the basins are large, inert areas that have been sunk by a slow, unbroken, and wave-like movement, with crests and troughs as waves which traverse slowly the crust of the earth.

3. That the abyssal deeps have been caused by abrupt faulting and volcanic fracture.

NOMENCLATURE.

This is always an important point in geography, and I have constructed the map exhibited, showing all the names that have been proposed and a few more which I suggest as probably useful.

The subdivision of terms employed is—

Plateaux	*a.* Slopes or shore plateaux. *b.* Oceanic plateaux.
Basins	*c.* Ocean channels and basins.
Deeps	*d.* Deeps.

The following is the list of names by which each of these is distinguished :—

Atlantic Ocean.

1. Ross Deep.
2. Havergal Deep.
3. Bromley Plateau.
4. Lizard Deep.
5. S. Georgia Plateau.
6. Falkland Island Plateau.
7. Wild Rise.
8. Buchanan Deep.
9. Challenger Plateau.
10. Connecting. Plateau.
11. Dolphin Plateau.
12. Moseley Deep.
13. C. Verde Plateau.
14. Monaco Deep.
15. Nares Deep.
16. Carib Basin.
17. Bartlett Deep.
18. Mexico Basin.
19. Luhm Deep.
20. Iceland Plateau.
21. Sub. Arctic Basin.
22. Nansen Deep.
23. Greenland Plateau.

Pacific Ocean.

24. Barker Basin.
25. Buchan Basin.
26. Juan Fernandez Plateau.
27. Harckel Deep.
28. Richards Deep.
29. Krümmel Deep.
30. Milne Edwards Deep.
31. Galapagos Plateau.
32. Albatross Plateau.
33. Grey Deep.
34. Hawaii Deep.
35. Challenger Deep.
36. Swire Deep.
37. Brooke Deep.
38. Tuscarora Deep.
39. Japan Basin.
40. China Basin.
41. Sulu Basin.
42. Philippine Basin.
43. Celebes Basin.
44. Banda Basin.
45. Moore Basin.
46. Caroline Plateau.
47. Ladrone Plateau.
48. Okhotsk Basin.
49. Solomon Island Plateau.
50. Carpenter Basin.
51. Momson Basin.
52. Enterprise Basin.
53 Maori Plateau.
54 Tasmanian Plateau.
55. Erebus Deep.

Indian Ocean.

56. Jeffry Deep.
57. Tobarton Deep.
58. Maclear Deep.
59. Kerguelen Plateau.
60. Rodriguez Plateau.
61. Seychelles Plateau.
62. Chagos Plateau.
63. Maldive Plateau.
64. Andaman Basin.

In conclusion.—The practical use of a more extended study of submarine geography is undoubted.

By gaining a familiarity with the geography of the sea bottom such as we have with land surface, how much the expensive work of laying telegraph cables would be rendered less liable to meet with failure.

And again, by tracing where land areas have disappeared or are now only expressed by an island archipelago, and by discovering the degree of antiquity of the movements by which this has been brought about, we might hope to restore the land connections that were in existence before and since the human race, and so afford somewhat sounder data than mere vocal sounds for the ethnologist with which to determine the lines of immigration by which the many recently formed varieties of the race have been produced. From every point of view, a clearer conception, founded on closer surveys of submarine geography both present and past, would be of great use to the zoologist and palæontologist.

No. 1.—SIXTY YEARS' PROGRESS OF GEOGRAPHICAL DISCOVERY (1837–1897).

By A. C. Macdonald, F.R.G.S., F.R.Hist. Society, Fellow of the Imperial Institute. Melbourne

(*Read Monday, January* 10, 1898.)

In every department of science rapid progress has been made during the past sixty years. The science of Geography, upon which I have been asked by my friend, Mr. Crummer, to address you to-day, has, during the past six decades, made vast strides.

In a letter dated the 8th July, 1837, the President and Council of the Royal Geographical Society of England, in offering their congratulations on the young Queen's accession, expressed their "heartfelt thanks for Her Majesty's generous condescension and munificence in granting the honor of her royal patronage, and in bestowing upon that Society a royal premium for the encouragement of geographical science and discovery. They confidently anticipated that Her Majesty's reign would be rendered illustrious as the era of important geographical discoveries which may diffuse the blessings of civilisation throughout the globe, as well as endear Her Majesty to the affections of a free and grateful people."

How fully this moderate and dignified anticipation has been fulfilled the record of the past sixty years attests. Her subjects,

and even those of other monarchs, have delighted to plant our Queen's name on the dominant features of the earth, as they have been unveiled in every land and in every sea.

On our modern maps there are now probably one hundred place-names of "Victoria," where in 1837 there were not more than half a dozen. The name "Victoria" was suggested for one of the hypothetical divisions of Australia, although about fourteen years elapsed before it was bestowed on the colony which now bears it. The name of our beloved Queen was given by James Clarke Ross to the most southerly-discovered land of Antarctica; and later to an inlet in Nares Land; and also to that part of the Arctic Ocean north of Alexandra Land in the farthest north. It is borne by flourishing commercial cities at both ends of the great transpacific route, in British Columbia and Hong Kong. It graces the largest lake in, and the grandest falls on the Zambesi, in Africa, the highest lake above sea-level in Asia, and it crowns the highest peaks of two of the mountain ranges in New Guinea and Equatorial Africa. The Colony of Queensland was also named in honour of Her Majesty.

It has been well said that "as Alexandria, the sacred city of early geography, perpetuates the memory of Alexander of Macedon, so will the name of Victoria on *our* maps, keep the Victorian era in Geography in everlasting memory."

The geographers of 1837 were a scattered band of distinguished explorers and men of science, whose enthusiasm was deeply stirred by the vast fields of research lying before them, buoyed up by the consciousness that they were labouring for the good of their fellow-creatures.

The explorer feels delight that he is on ground hitherto untrodden by man, that at every step he makes will serve to enlarge the sphere of human knowledge, and that he is laying up for himself a store of gratitude and of fame.

Maury, in America, was engaged in the studies which led to his great work on the Physical Geography of the Sea. In Great Britain—Parry, Franklin, Back, and Ross were famous Arctic heroes; Biscoe had awakened interest in the Antarctic regions; Murchison and Charles Darwin were already recognised as clever observers, and the great Arrowsmith was producing his exquisitely engraved maps, such as have not gladdened the eyes of geographers for a generation past: British travellers were in all parts of the earth. Ainsworth (who died only the year before last) was exploring Asia Minor, Everest was pushing on the great trigonometrical survey of India, which has fixed his name on the greatest mountain in the world—Mount Everest, 28,994 ft. high.

Africa had just claimed as a victim the intrepid Davidson while making his way across the Sahara to Timbuctoo, and British surveying ships were engaged in constructing for the whole eastern

and western coasts of Africa, from Suez round the Cape of Good Hope to the Pillars of Hercules, charts which may be said "to have been drawn and coloured with drops of blood," so terrible was the mortality amongst the crews before the elements of tropical hygiene had been learned.

A glance at the maps of Africa in 1837 and 1897 (on the wall) will serve to show the marvellous progress of geographical discovery during the sixty years' reign of Queen Victoria. Egypt, to the Second Cataract on the Nile, the Barbary States, and part of Abyssinia were amongst the limited portions of that dark continent then known to Europeans. Little was known of South Africa, beyond the Orange River north of Capetown, prior to 1837, when Sir James Alexander made a journey through Namaqualand of 1,500 miles; with these few exceptions the map of Africa was a blank. Cartographers had laid down the imaginary mountains of the moon, stretching almost across the continent from the Atlantic to the Indian Ocean, and also another range which they called "Laputa, or the backbone of the world," features that we now know had no existence. Nearly all the ancient maps were drawn from imagination, and I dare say many of our modern maps of the land boom period were more or less so, as many of us know to our cost.

Very little of the interior of this great Australian continent was known in 1837. Hume had discovered in 1824 one of our largest rivers, which bore his name for many years, but which Captain Charles Sturt subsequently traced to the sea from its junction with the Murrumbidgee in 1829–1830, naming its lower portion after Sir George Murray, the second president of the Royal Geographical Society of England. Sir Thomas Mitchell, then Surveyor-General of this Colony (New South Wales), in 1836 discovered Australia Felix, now the colony of Victoria. Numerous exploring parties were in the field in these early years, and a town called Melbourne was laid out in 1837 on the north bank of the river Yarra, in what was then, and for many years afterwards, in New South Wales territory. Grey and Lushington's expedition on the north-west coast of Australia was in progress, and the rest of the map. central, northward, and westward, like that of Africa was an unknown blank.

The interior of Australia has, thanks to the munificent generosity of the late Sir Thomas Elder, and Messrs. Horn, Calvert, and Carnegie in a lesser degree, been opened up, save a few patches of desert in the west, entirely within the period under review. Nowhere has more heroism been shown by explorers, and no explorers have received scantier recognition by the public than those who have made known the interior of the "only entirely British continent." The names of Eyre, Hume, Sturt, Leichhardt, the two Gregories, Macdouall, Stuart, Burke and Wills, Forrest,

Giles, Lindsay, Wells, Landsborough, the Honorable D. W. Carnegie, and others, are too unfamiliar to English, and, indeed, Australian readers also, although nearly all have been honoured by Geographical authorities, and the romance of their exploits will some day let us hope be adequately told by an Australian historian.

The great island of New Guinea has been to a large extent explored by the British, Dutch, and Germans, who administer its various divisions and the present Lieutenant-Governor, Sir William Macgregor, "has earned for himself a place in the history of the island only comparable to that of Livingstone in the history of Africa." Mr. Theodore F. Bevan has also done good work in British New Guinea as an explorer. The success of the expedition was largely due to the perseverance and indomitable energy of Mr. Lawrence Hargrave, who accompanied D'Alberti on his expedition up the Fly River, as engineer of the steam launch.

In South America vast tracks of country were entirely unknown and the courses of the many navigable rivers in the interior were undiscovered sixty years ago. In the Indian and Pacific Oceans many islands were practically unknown and little or nothing of New Guinea—as I have said before—had been explored.

Time will not admit of my doing more than merely glancing at one aspect of the progress of Geography during the sixty years of the Victorian era ; and perhaps the best aspect is that of discovery and exploration for in it British work has been preeminent.

The problems of general scientific geography formulated by the President of the Royal Geographical Society in 1837 and put forward by him as deserving of immediate attention are to a discouraging extent still problems of the future. This has been largely due to the lack of international co-operation, and the mutual independence of the workers in different countries—a state of things which the development of international congresses in recent years may be hoped soon to improve.

Until James Clarke Ross's expedition in 1839, nothing was known of the Antarctic region, except where Cook had reached the 70th° and Weddell the 74th° parallel of south latitude.

The history of Antarctic discovery opened with the accession of Queen Victoria to the throne. Ross, who had previously spent eight winters in the Arctic—and had passed no less than sixteen navigable seasons in the polar regions, left England in 1839 and crossed the Antarctic circle on the first day of January, 1840. "In the short space of one month made one of the greatest geographical discoveries of modern times—amid regions of perpectual ice he discovered a southern continent which he named South Victoria Land—two volcanoes, one of which in a state of active eruption, 12,400 feet high, he named after his ship the

"Erebus." Since Ross's return, by way of Hobart in 1842, no expedition worthy the name has been sent out to continue his work.

We frequently meet people who ask "what is the use of spending money in Antarctic exploration?" One of our millionaire squatters when asked recently to subscribe to that object replied—"Oh, whats the good! there's no sheep or cattle country so far south"! I have little sympathy with those of our wealthy colonists—many of them Australian born—who are so wanting in patriotism and so densely ignorant of the vast results to be obtained by Antarctic exploration. In this connection I cannot do better than quote from Sir Clements Markham's annual address before the Royal Geographical Society of England in May of 1895. Mr. Markham said:—"Of late years the necessity for an Antarctic expedition has become more and more urgent for many reasons, but chiefly because the science of terrestrial magnetism is at a standstill, owing to the absence of any observations in the far south during the past fifty years. The knowledge which would be gained by such a magnetic survey will not only be of scientific interest, but it will also be of practical importance to navigation. Deep-sea soundings, dredgings, temperatures of the ocean at various depths, meteorology, the distribution of marine organisms, are some of the investigations which would be undertaken by an Antarctic expedition with reference to the ocean. Equally important objects would be to determine the extent of the south polar land, to ascertain the nature and extent of its glaciation, to observe the character of the underlying rocks and their fossils, and to take meteorological observations on shore.

"As the geographical history of Queen Victoria's reign commenced with Antarctic exploration, so the sixtieth year from Her Majesty's accession should be worthily commemorated by preparations for continuing the exploration of the southern continent which bears the name of our Queen."

The cablegrams that have appeared in our Sydney and Melbourne daily papers during the past few months indicate that the Royal Geographical Society of England has been influenced by Sir Clements Markham's address. An appeal has been made, or is to be made, to the Imperial Government, and also to the Governments of the Australasian colonies, for their co-operation and financial support, and the Royal Geographical Society has headed the list with a subscription of £5,000. In the cause of science which is cosmopolitan, and in the carrying out of a project so pregnant with scientific and commercial good to Australasia, all local feeling and prejudice should be cast away. Let this Association see to it that the glory of making discovery and exploration in these southern seas be not borne from us by others, to our everlasting discredit. It would, I think, be a step in the right

direction if this Association were to appoint a committee to co-operate with the Antarctic Committees in Melbourne and London, and address the several Australasian Governments upon the subject.

The polar work of the last sixty years has been of surpassing interest and of immense importance. In other parts of the world, the ceaseless activity and zeal of her subjects has also rendered Her Majesty's reign a memorable epoch in the record of human progress. On the Asiatic continent one generation after another of British surveyors and British explorers has pushed forward our knowledge, and the work is now approximating completion.

The trigonometrical survey of India is the grandest monument of the Queen's reign on the Asiatic continent. When Her Majesty ascended the throne Colonel Everest was succeeded by General Walker, who has since completed the principal triangulation of India. This great work presents a record which forms one of the proudest pages in the history of British domination in the East. "We look back," says a recent writer, "with pride and admiration upon the Asiatic labours of the Queen's geographical subjects." The geological and natural history survey of Canada, under the late directorship of A. R. C. Selwyn, formerly head of the Geological Survey Department of Victoria, is second in importance to that of the trigonometrical survey of India.

Arctic exploration has always been viewed with interest and often with enthusiasm, but never have the romance and tragedy of exploration held so sustained a hold upon the world as during the fifteen years which followed the departure of Sir John Franklin in 1845. In that year the "Erebus" and "Terror," just returned from the Antarctic, sailed to complete the survey of the Arctic coast of America, and achieve the North-west Passage, "the vain dream of the merchants of the sixteenth century."

Towards the end of the summer of that year (1845) they were seen by a whaler in Melville Bay, and this was the last direct news of that ill-fated expedition. In 1848 Sir James Clarke Ross started on the first search expedition, and during the next few years ship after ship went out through Lancaster Sound on the east and Behring Strait on the west, while land parties, under the guidance of the Hudson's Bay Company, whose officers were exploring the Arctic coast of America.

The Arctic Archipelago was very fully explored in this way. In 1850 no less than fifteen vessels were prosecuting the search for the missing Franklin Expedition, and in that year Captain McClure, who went out by way of Behring Strait in the "Investigator," discovered the North-west Passage, but he found the ice conditions so severe that he had to abandon his ship and return by one of the vessels pursuing the Franklin search from the eastward.

Five years later (1855), after relics of the lost ships had been found by Dr. Rae, the British Government abandoned the search, but the devotion of Lady Franklin, and the determination of the public to discover fuller details, led to the splendid private expedition of the "Fox," from 1857 to 1859, in which Sir Leopold McClintock and Sir Allen Young explored nearly 1,000 miles of new coast line under conditions of the greatest difficulty, and discovered the only document throwing light on Franklin's fate which has been found. It proved that to Franklin belongs the honor of first discovering the North-west Passage.

In 1871 Captain Hall, in the American steamer "Polaris," entered Smith Sound, and reached the highest latitude so far attained (82° 16′ north). In the following year an Austro-Hungarian Expedition, under the command of Payer and Weyprecht, were carried by drift ice from Nova Zembla, and discovered Franz Joseph's Land, the remote region in which the English explorer Jackson and his party have been at work during the past three and a half years.

The Great British Government Expedition of the "Alert" and "Discovery," under Sir George Nares, penetrated Smith Sound in 1875, and Commander A. H. Markham led a sledge party to 83° 20′ north of Greenland, which remained the highest observed latitude until Lockwood, of Greeley's American Expedition, reached 83° 24′ in 1882. In 1878–9 the Swedish professor Baron Nordenskiold accomplished the North-east Passage in the "Vega," and circumnavigated the continent of "Eurasia" for the first and only time. Peary, in three successive years (accompanied part of the time by his wife), made some of the finest journeys ever accomplished over the inland ice of Northern Greenland. Great as these achievements were, they have been excelled by the scientifically-planned expedition of Dr. Nansen in the "Fram." By relinquishing the time-honoured plan of following a coast line, or fighting against drifting ice-floes, and allowing the moving ice of the polar basin to carry his ship, he succeeded in drifting from near New Siberian Islands to Spitzbergen across an absolutely unknown area. In his sledge journey, alone with his companion Johansen, he reached 86° 14′ north in 1895, an advance of nearly 200 miles on the farthest north ever made before; and his expedition, in its safety, success, and exact conformity to the plans previously laid down, must be looked upon as the culmination of Arctic travel in the Victorian era, unless, as I fully anticipate, it will be equalled, if not eclipsed, by the balloon voyage of Dr. Andree.

Next to the polar areas, Africa is the region in which the explorations of the last sixty years have led to the most striking advances of knowledge. The trade of centuries on the west coast had led to no exploration worthy the name, and it was not until

the missionary travels of Dr. David Livingstone in the fifties that any real interest was evinced in the continent as a whole. As a pioneer of African discovery, Livingstone may be looked upon as the initiator of the modern period, and in his methods of work and his treatment of natives he remains a model for all time. His discovery of Lake Nyassa in 1859, Burton's discovery of Tanganyika in 1858, Speke's of the Victorian Nyanza in 1862, threw open the great Lake region of East Africa along its whole length; and the main lines of the geography of the eastern strip of Africa, under the rule of the Sultan of Zanzibar, were quickly laid down by an increasing number of explorers.

The sources of the Nile have exercised a fascination for travellers in Africa like that of the search for the North-west Passage or the North Pole for Arctic voyagers.

Livingstone with the assistance of the faithful Makololo tribe started in 1854, from Luanda, on his memorable journey across Africa down the Zambezi. The wonderful falls of that river, more splendid even than Niagara, received from Livingstone the name of Our Queen. In his second journey, accompanied by Sir John Kirk, he ascended the Shiré River, discovered Lake Nyassa and the highlands, attaining a height of 6,000 feet. The wishes of the discoverers were amply fulfilled in the subsequent history of Nyassa Land where there is now a flourishing colony with steamers on its rivers and lakes, an increasing trade in ivory and coffee, law and order fully established under the able administration of Sir Harry Johnstone, and every prospect of increasing prosperity in the future.

Livingstone and Sir John Kirk traced the great river Lualaba which flowed northward, west of Lake Tanganyika to its source in Lake Bangweolo, when death overtook Livingstone in 1873. Believing this great river was the Nile he could not yet resist the suspicion that it might after all turn out to be the Congo. This supposition was turned into certainty by Mr. H. M. Stanley's magnificent journey in 1877. When he traced the Lualaba round its great Equatorial bend, and opened up the vast waterway from Stanley Falls to Stanley Pool on his way to the sea.

Verney Lovat Cameron who went out to search for Livingstone in 1872, made a remarkable journey in the interests of geographical discovery, after he had ascertained without doubt, the great explorer and missionary was no more. He was the first European traveller who walked across the African Continent from east to west, a journey occupying 3 years and 5 months—but no journey i Africa has been so fateful as that of Stanley, down the Congo, it led to the foundation of the Congo Free State and the opening up of the whole great river to steamer traffic, affording a base from which the northern and southern tributaries could be explored to their sources.

In 1884 commenced the scramble of the European Powers for African possessions and the resulting partition of the coast into spheres of influence, whence the explorers of each nationality pushed inland in the effort to secure the hinterland and command the sources of internal trade. The remotest deserts of Sahara, isolated parts of Equatorial forests and portion of Somaliland are the only regions now remaining entirely unknown.

South America was, of all continents, the most rapidly explored as far as its main outlines are concerned—(on the great watershed of the Amazon River there are tracts of unexplored country as large as the whole of France, of which we as yet know less than of almost any equal area on the globe. Tribes of men are living there who are yet absolutely in the Stone age, and who, even by barter or distant rumour, never heard of the European race or the use of metals)—and such work as has been done within our period has been chiefly the better mapping and more complete tracing of river systems, the climbing of mountains like Roraima, Chimborazo, and Aconcagua, and the exploration of the wilderness of the Grau Chaco and Patagonia.

Schomburgk was engaged in surveying the western frontier regions of British Guiana and stirring up a controversy, the end of which it is, perhaps, not unduly optimistic to look forward to in this the 61st year of Her Majesty's reign.

The naturalist geographers of South America did not die out with Humboldt. The works of Wallace, Bates, and Von den Steinen in the Amazon district, Schomburgk and Im Thurm in British Guiana, Burmeister and Hudson in the Argentine Republic, will never be forgotten.

Time will not admit of my doing more than merely mentioning the great science of Oceanography in the Victorian era. The cruise of the "Beagle," with Darwin on board, may be said to have passed on the torch kindled by Cook to the Antarctic Expedition of Ross. Observations made casually in these cruises were systematised by Maury, who, with the force of his magnificent enthusiasm, has given a vitality to his "Physical Geography of the Sea" which enables that unique work to survive the theories it propounded. The voyage of the "Challenger," and the progress of telegraph surveys, gave a secure basis for the study of Oceanography, and many minor expeditions have since advanced it. The time is now ripe for another well-organised and fully-equipped expedition for the study of the oceans, a subject so ably dealt with by Sir James Hector in his Presidential Address delivered in this hall on Friday last.

The phenomenal progress of Japan in Western civilisation has led to a vast advance in geographical knowledge concerning that remarkable archipelago, and slower progress has been made in

the rich islands of the Malay Archipelago, where the travels of Wallace have been followed by the researches of many other naturalists.

Nor can I refer in detail to explorations in Central Asia, the United States, Canada, and elsewhere, and although I feel I have trespassed too much on your patience, it would be impossible to conclude this imperfect sketch of the sixty years' progress of geographical discovery without saying a few words on the services to geography rendered, during the Queen's reign, by those of her own sex. At the accession, Mrs. Somerville was the best physical geographer in Great Britain, and her distinction won for her the gold medal of the Royal Geographical Society in 1869, an honor only accorded to one other woman—Lady Franklin. In 1842, Frau Ida Pfeiffer commenced her wanderings, which covered almost every quarter of the globe and led to a number of popular books of travel. Since then, Miss North followed in Madame Pfeiffer's footsteps in search of flowers to study and paint in all climates, Miss Gordon-Cumming, the late Lady Brassey, the indefatigable Mrs. Bishop, and Miss Kingsley have performed feats of travel far beyond the averages of globe-trotters or pleasure-seekers. Lady Baker accompanied her husband on his expedition up the Nile to the Equator, and Mrs. Peary stayed by her husband during an Arctic winter in Northern Greenland. The ill-fated Mdlle. Tinne lost her life in the attempt to penetrate the Sahara, Mrs. Theodore Bent has accompanied her husband into parts of Africa and Arabia, where no white woman has been before. Lady Anne Blunt in another part of Arabia rendered real services to geography.

It would be impossible to enumerate the noble company of lady missionaries, who have followed hard on the explorer and trader into the inmost recesses of Africa and Asia, sometimes, as in the case of Miss Taylor, who went far into Tibet even opening up entirely new ground.

The great names of British and Australian geographers and explorers at the beginning of the reign find worthy counterparts at the 60th anniversary. Men of the originality of Francis Galton, the versatility and wider knowledge of Sir Clements Markham and Hugh Robert Mill, and the scientific strength of Dr. John Murray, of the "Challenger;" nor are the names of General Strachey, Admiral Wharton, Ravenstein, Bartholomew, and the late Baron von Mueller likely to be soon forgotten, or their influence on the progress of geographical science to be effaced.

Everywhere, the scientific geographers of the present day are more numerous than at any previous time. In physical geography Suess and Penck in Austria, Richthofen and Supan in Germany, Dr. Lapparent in France, and W. M. Davis in the United States

are representatives of the most modern developments of geography. Elisée Reclus must also be mentioned as the author of the most important treatise on general geography of modern date ; and only the impossibility of adding names to a paper already overburdened with them, prevents me paying a well deserved tribute to a hundred others.

In the preparation of this paper I have availed myself freely of Sir Clements Markham, Hugh Robert Mill, and W. M. Davis of America. In some places I have quoted their own words, and I desire to express my indebtedness for such valuable information.

No. 2.—OVER LAND AND SEA; or ANDRÉE'S AERIAL VOYAGE TO THE NORTH POLE.

By A. C. Macdonald, F.R.G.S., F.R. Hist. S., F.I.I., etc.

(*Read Monday, January* 10, 1898.)

No. 3.—REMARKS ON CENTRAL AUSTRALIA, SUGGESTING FURTHER EXPLORATION.

By W. H. Tietkens.

(*Read Wednesday, January* 12, 1898.)

Notwithstanding the labours of the past, the last volume of Australian discovery is still incomplete. When written it will be found replete with accounts of intrepid deeds of daring and contempt of danger, and future generations will become acquainted with the difficulties and privations which their pioneer ancestors faced in their endeavours to solve the mysteries of the unknown interior.

The chapter so recently closed is full of tragic interest ; how nobly those brave men (Charles F. Wells and George L. Jones) met their death on the burning sands is an occurrence still fresh in the minds of us all, and affords a fitting opportunity for this association to offer a tribute to the memory of those devoted men who fell in the Calvert Expedition of 1896.

The early explorers of the eastern parts of Australia have had their labours rewarded by knowing that the waggons and flocks of the pastoralist followed in their footsteps. Those who were the first to travel west of the overland telegraph line have been

less fortunate, for instead of the pioneer settler we now, profiting by experience, find explorers, with more elaborate equipment, journeying in other latitudes, hopeful that a more fertile country will reward their labours.

It would nevertheless appear that there are discoveries yet to be made that will open out an extended field for employment and enterprise.

No settlement has yet been effected to the northward of the Great Australian Bight.

The formation of crystalline limestone which there prevails extends northwards for over 100 miles; this has been tested by the South Australian Government for water, to a depth of more than 1,000 feet, but without success. There are no surface clays in which reservoirs could be made. The rainfall is less than 6 inches per annum, so this extent of country may be said to be waterless. Continuing northwards, after passing over these Limestone Plains, the traveller enters a sandhill country, covered with various leguminous trees and shrubs, and the ever-prevailing and dreaded spinifex. With the exception of a few outcrops of rock where water may be found, or an occasional native well, this tract may be said to be almost waterless. Such waters are difficult to find, and for the most part they barely supply the wants of a passing caravan. This description of country continues with unbroken monotony to about south latitude 29° 15′, when mountain ranges of 2,000 feet are met with. These extend east and west almost uninterruptedly for a distance of over 200 miles; they are known as the Musgrave, Mann, Tomkinson, and Cavanagh Ranges. Their rugged slopes are torn and riven by the torrents of water that pour down in times of the phenomenal rains which occasionally fall in those regions. Large creeks issue from the gorges, and, flowing southward, are swallowed up and absorbed by the vast banks of sand which, rolling up from the southwards, defy the torrent to force its way through them. These ranges were discovered in 1874 by the expeditions under Gosse and Giles. Very heavy rains must have fallen just previous to their visit, for there was water in abundance, grass and herbage were green and luxuriant, nearly every creek and gully was a purling brook, and, for the time being, there was relief from the anxiety which the continued search for water entailed.

These conditions prevailed until the west extremity of the range at Elder's Creek was reached. Further progress westward was then checked by a waterless, sandy waste that appeared to extend indefinitely towards the west.

Giles turned to the northward, and, after travelling over 80 miles, discovered and named the Rawlinson Range, in latitude 24° 40′, which, with the Petermann Range, extend in an east and west direction for nearly 200 miles. At the west extremity of

the Rawlinson a sandy waste was encountered which defied every effort to traverse. At this point, in his endeavour to cross to the westward, his only companion (Gibson) lost his life. The hardships of that journey may be conceived when we remember that the return journey of 100 miles to the Rawlinson was completed by Giles on foot and alone. In the following year, however, Giles, provided with camels, crossed with comparative ease from the west.

This waterless waste appears to extend, perhaps, to the watershed of the River System, which flows northward to the Timor Sea. It was traversed by Colonel Warburton in 1873. The record of that journey is one of privation, anxiety, and distress. The few native watering places found barely sufficed to supply the wants of the party even for a day.

The private expedition fitted out, maintained, and led by the Hon. David Carnegie, which has just returned to the settlements, has largely added to our knowledge of the country northward of the Rawlinson Range. It appears to be the most successful of all recent desert journeys. The diaries are not yet available, but we learn that the party of four men and a black-boy left Coolgardie in July, 1896, and travelled to the Margaret River, latitude 18° south longitude 126° east, and to Termination Lake of Gregory, 1856. From this point the party travelled south-westerly to Lake MacDonald, to Alfred and Marie Range, thence to Lake Darlot and Coolgardie, where they arrived in August, 1897. The country between Termination Lake and the west end of the Rawlinson is described as of the "worst class, holding out no hope of being either of mineral or pastoral value."

It is worthy of remark that a native population, necessarily very scattered, will be found living in the sandy wastes which occupy so vast an extent of country in the interior. The few who granted us an interview were sinewy, lithe, and well made, possibly they are compelled to travel great distances without water, but they had not the appearance of being at any time reduced to want.

The only part of the Australian continent of any extent which appears unable to support a native population is the Limestone plateau, north of the Great Bight already referred to.

The trigonometrical survey of South Australia has been extended to the 129th meridian upon the Musgrave and Mann Ranges; these have recently been visited by Mr. S. G. Hübbe, an experienced officer of the Lands Department of South Australia. His very carefully prepared maps and journals have been kindly forwarded to me;—they give valuable detailed information regarding the waters in these ranges. The object of this survey was to ascertain the possibility of establishing a stock route from the settlements of South Australia to those of the west.

The season was not a favourable one, but it would appear that any waters that were found were not of sufficient extent or volume to encourage the hope that stock in any numbers could venture to adopt this route with any degree of safety.

So many travellers have visited these ranges at different times, especially since the gold discoveries in Western Australia, that it may now almost be termed a highway between the two colonies.

It would be well, then, to turn our attention to the two mountain chains—the Rawlinson and Petermann Ranges—that lay to the north of the Mann and Tomkinson Ranges, and which are bounded on all sides by such barren and inhospitable sandy wastes, where the powerful rays of the sun scorch the stunted vegetation, and which may be said to be the birthplace of the hot wind "that scatters death on all that yet can die." To the best of my belief, these ranges have not been visited, except by Giles, whose party was much reduced :—he had been at that time nearly twelve months in the field, one man had perished, as also had many of the horses, provisions were exhausted, and the members of the party were subsisting principally upon the flesh of their worn-out and exhausted horses. Under such circumstances, close examination of the country was impossible. Many large gum creeks were crossed, all trending to the northwards. These were erroneously charted as running into Lake Amadeus, which was supposed to lie in that direction.

In 1889, an expedition which I had the honor of leading, was fitted out under the auspices of the South Australian branch of the Royal Geographical Society, one object of which was for the purpose of determining the outline of Lake Amadeus. The most westerly point reached on this occasion was Mt. Leisler, 2,500 feet, in south latitude, from the summit of which the view in all directions was over an expanse of sand, scrub, and waterless country. This mountain is a conspicuous feature from any point of observation for very many miles, and serves as a beacon warning the traveller against approaching its dreary surroundings. Sandhills roll like the tumultuous waves of the ocean up to its very base; the scene is one of silent, barren desolation. From this point the travellers turned south-easterly towards Mt. Unapproachable, and there found the west extremity of Lake Amadeus, which we now know contains an area of about 900 square miles; that it is about 1,000 feet above the level of the sea; that no water channel of any consequence empties into it, and that it is surrounded on all sides for very many miles by the most inhospitable spinifex sandhills.

The Petermann Ranges extend east and west for about 70 miles and may be said to be the eastern continuation of the Rawlinson chain. They are more remarkable for their extent than for great elevation or their imposing outline. From Mt.

Olga they would perhaps not even be seen, but they gradually increase in height until the Rawlinson Range is reached. Here, then, is an extensive and fertile field awaiting scientific and systematic examination, in which much that is now a matter of conjecture requires to be verified.

An expedition such as that fitted out by Mr. W. Horn, of South Australia, is required for the work. The party equipped and maintained by the above-named gentleman called for savants from the Universities of each of the colonies, New South Wales being represented by Mr. J. A. Watt, M.A., B.Sc. This party was most ably conducted by Mr. C. Winnecke, of Adelaide, and returned after its four months' ramble in the Macdonnell, Krichauff, and Gill Ranges rich in discovery to every branch of science.

An opportunity here presents itself to those upon whom fortune has largely smiled to shed the lustre of discovery upon their names by the equipment and maintenance of an expedition that shall have for its object scientific search in this almost unknown region. Such a party would leave the settlements at Gill's Range or Erldunda and proceed from there to Mt. Olga, where the first depôt would be formed pending the discovery of a suitable water being found further west, and nearer the scene of operations. No difficulty would then be experienced in reaching Sladen Water. It may almost be taken for granted that valuable waters would be found before reaching so far west. From the western end of the Rawlinson, the party would return by a slightly different route, and if time and circumstances allowed, before leaving Sladen Water light parties would be formed to visit Fort Mueller to the south, and Mt. Leisler to the north. Taking advantage of the winter months by being at Mt. Olga in April, the party would return to the settlements before the excessive heat of summer.

It is with the hope that it will lead to a close examination of this country that these remarks are offered. The discovery of gold-bearing rocks in Western Australia in country that had been traversed by such close observers as Gregory Austin, Lefrey Forrest, and many others, leads me to think that somewhat similar conditions will prevail here, for we know that where Devonian slates, sandstones, and granites protrude, precious metals impregnate the fissures to a greater or less extent.

The conviction is now forced upon us that no pasture lands of sufficient extent may be looked for that would develop the western interior, but we may reasonably entertain the hope that the mining industry in this latitude will challenge the enterprise of the Australian people.

No. 4.—A CONTRIBUTION TO AUSTRALIAN OCEANOGRAPHY.

By Thomas Walker Fowler, M.C.E., F.R.G.S., F.G.S., &c.

(Read Wednesday, January 12, 1898.)

On examining the reports of the "Challenger" Expedition some two years ago, it appeared to the writer that there was still room for a large amount of investigation in connection with Australian Oceanography, and more especially as to the currents, densities, and temperatures of our seas. The "Challenger" touched at few points in Australia and New Zealand (Melbourne, Sydney, Wellington, and Cape York), and these points were each visited but once, so that a complete examination of our waters was not made during that expedition. To make such an examination would, probably, have taken up considerably more time than that occupied by the whole "Challenger" Expedition in the voyage round the world. The scientists engaged in preparing the "Challenger" reports had, of course, access to observations other than those taken on board that ship, but there appeared to be room for much further work. The writer has endeavoured to advance the work a little, more especially with the view of ascertaining the variations in temperature and density of our waters.

Necessarily, the method adopted in obtaining information was very different to that followed on the "Challenger." Being only able to devote spare time to the work, the writer was unable to visit in person the different localities from which it was desirable to obtain samples. He, therefore, applied to the captains or officers of various intercolonial steamships proceeding at regular intervals along the Australian coasts for assistance, which they kindly granted by obtaining samples of the waters passed through by them and noting the temperature of the sea at the time each sample was obtained. The samples were obtained as near to the vessel's bows as possible and placed in well-cleaned bottles which were tightly corked and forwarded to the writer for examination at the Melbourne University.

After careful consideration the writer decided to determine the densities by means of a hydrometer provided with movable weights. This was the method adopted by Mr. Buchanan on the "Challenger." Previous to arriving at this decision, the advisability of using other methods, such as Sprengel tubes, was thought of, but laid aside as impracticable, considering the

number of samples to be dealt with in a short time. Experiments were also tried with a modified type of the Nicholson hydrometer, the fiducial point being a glass pointer projecting upwards from the hydrometer bulb instead of a mark on the stem as usual. The contact of this pointer with its reflection at the surface of the water, as seen by looking upwards through the hydrometer glass, could be observed with very great precision, the whole arrangement being similar to that of the fiducial point of a Fortin barometer inverted. The ease with which separate determinations could be obtained by Mr. Buchanan's method, using different weights, caused the writer to finally adopt it. The hydrometers used were two in number, the first having a volume of $90\frac{1}{2}$ cubic centimetres with stem diameter of, approximately, 5 millimetres, and the second a volume of $137\frac{1}{2}$ cubic centimetres, with stem diameter of, approximately, 4 millimetres. Both instruments were made by J. Hicks of London. The diameters of the stems were carefully measured by micrometer gauges and the distances between the graduation marks verified on arrival of the instruments in Australia, and the accuracy of the zero graduation verified by testing in distilled water. From the above information and the weights in vacuo of the hydrometers and weights used (which were carefully obtained), the value of each stem-reading of the hydrometer for each applied weight was ascertained. These were checked by testing the instruments in solutions of known densities. The hydrometers are standard at 60° Fahr., and the corrections to apply to readings taken at other temperatures were carefully determined by experiment. The densities were determined, as far as possible, when the surrounding temperature did not differ greatly from 60 degrees.

The observed densities are given in the attached tables, A to F inclusive, and are means of three readings of the hydrometer with different weights in each case. In almost every case the results obtained with the large hydrometer for each individual reading does not differ from the mean by more than 0·0006, the average difference being about half of this amount. With the small hydrometer these figures would be doubled. The densities given throughout are those of the sea-water at 60° Fahr. referred to distilled water at 39·2° Fahr. as standard. The temperatures given are those reported by the gentlemen obtaining the samples, all of whom were carefully instructed as to the importance of reading the thermometer whilst the bulb was in the water. The thermometers used were ordinary ship's thermometers, the special thermometers which the writer had ordered not being available in time. Attempts were made to obtain the samples in the months of February, May, August, and November, as being months when the greatest variations (*i.e.*, in February and August), and mean results (*i.e.*, in May and November) might be expected.

Tables A give results obtained between Fremantle and Melbourne.

Tables B give results obtained between Melbourne and Bris bane.

Tables C give results obtained north of Brisbane.

Tables D give results obtained between Melbourne and The Bluff, N.Z.

Tables E give results obtained between The Bluff, *via* East Coast, N.Z., and Sydney.

Table F give results obtained from samples taken by the writer in Bass Straits, off Sorrento.

Samples A to M (Table F) and Nos. 1 to 165 and 202–4, all inclusive, were tested with the small hydrometer, all others with the large one.

An examination of Tables A, will show that the density in St. Vincent's Gulf is always considerably higher than in the Great Australian Bight, whilst the latter shows a lower density generally in November, 1896, than in the previous August or May. In May only do we find traces of the high density shown by Dr. Buchan in the "Challenger" reports as existing on the west coast of Australia. Tables B show lower densities between Melbourne and Brisbane in December, 1896, and March, April, and May, 1897, than in May and August, 1896. Tables C show throughout a remarkable drop in density on passing north of Mackay, Queensland, due, no doubt, to the heavy rains discharged by the coast rivers into the sea within the Barrier Reef. Tables E disclose a remarkable rise in temperature and density at latitude 46° 16′ S. and longitude 165° 46′ E. in May, 1896, and peculiar variations in both temperature and density at this locality in November, 1896. One is tempted to speculate as to the existence of any peculiar currents in this locality. Tables E show very clearly the increase in density in passing through Cook Strait from the east coast of the South Island of New Zealand, westerly towards Sydney.

Table F gives a series of density determinations made by the writer on waters obtained by him in Bass Strait, and are interesting as showing the variations met with at one spot. The writer has made these determinations as often as possible, and the series, Nos. 258 and onwards, are specially interesting, as the observations were made almost daily.

Table G gives a series of sea temperature observations taken by the writer in Bass Strait. Observations of this character are useful in determining the positions of the surface isothermal lines of the ocean at different periods of the year. The results

obtained lead the writer to suspect that errors are frequently made in observing sea temperatures, either by withdrawing the thermometer from the water prior to noting the reading, in which case evaporation commences, and the reading obtained is too low, or by letting the sun's rays reach the thermometer when in the water (usually contained in a bucket), in which case the reading will be too high.

The information contained in the attached Tables is, of course, very incomplete, and the writer is fully aware that only by years of close observation and study can a full knowledge of Australian Oceanography be obtained. That the study will be of practical utility ultimately, he has no doubt. The immense volume of water situated to the south and west of Australia must have very powerful influences on the seasons experienced in the southern portions of the continent. A very slight increase in temperature of the ocean must exert a considerable effect on the seasons, giving a mild winter or hot summer, whilst the density of the waters will affect the rate of evaporation therefrom, increasing or diminishing the moisture in the atmosphere. It seems, therefore, important to have observations of at least the temperature of sea-waters taken regularly as an important meteorological element. To be of use, however, such observations must be taken at stations properly exposed. The results, for example, obtained at the Gellibrand Lightship, Melbourne, are affected largely by the temperature of the river Yarra, and probably those obtained in Sydney Harbour are similarly affected by the Parramatta River. Observations made at many of the coast lighthouses would be free from the objection, but great care should be taken that the temperature observed is of water drawn from the sea itself, and not from shallow pools left by the ebbing tide.

The writer is deeply indebted to Captains Armstrong, Lee, Rossiter, and Thomson, of the A.U.S.N. Company's service, and Captain Phillips, of the Union S.S. Company's service, also Chief Engineers Burwood and Orr, of the former company, for their kindness in obtaining samples and observing temperatures. He is also deeply indebted to Messrs. D. Mills, of the Union S.S. Company, Melbourne, and C. W. McLean, A.M.I.C.E., of the Marine Board, Melbourne, for valuable assistance. Captain T. H. Tizard, R.N. and F.R.S., of the Admiralty Office, and R. H. Scott, Esq., F.R.S., of the Meteorological Office, London, and the Superintendents of the Fish Commission and the Coast and Geodetic Survey, Washington, have supplied very valuable information. Messrs. Ellery, F.R.S., and E. J. Love, F.R.A.S., as well as Professors Kernot, Lyle, and Masson, gave most valuable assistance and advice. To all of these gentlemen the writer has to tender his sincere thanks.

Table A 1.—Densities of Waters obtained between Fremantle and Melbourne, May and June, 1896 :—

Note.—The latitudes and longitudes given are those recorded by the gentlemen who obtained the samples. In some cases they correspond with positions remarkably close to or on land, but they still will indicate the localities from which the samples were obtained. Opportunities of checking them, except by chart, have not arisen, and it was thought better to give the actual record with this note.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
1	12 May	32 3	115 45	...	1·02641	Near Fremantle.
2	13 ,,	34 25	115 29	...	1·02619	,, Cape Leeuwin.
3	14 ,,	35 19	126 17	...	1·02607	Australian Bight.
4	15 ,,	35 17	130 15	...	1·02595	,, ,,
5	16 ,,	35 28	135 9	...	1·02579	,, ,,
29	17 ,,	35 27	134 25	60	1·02589	,, ,,
30	17 ,,	35 24	131 28	64	1·02573	,, ,,
31	18 ,,	35 15	129 26	60	1·02589	,, ,,
32	18 ,,	35 12	127 5	58	1·02589	,, ,,
33	19 ,,	35 10	124 44	62	1·02624	,, ,,
34	19 ,,	35 11	122 8	62	1·02598	,, ,,
35	20 ,,	35 10	118 52	62	1·02619	
36	21 ,,	35 9	117 9	66	1·02638	
37	21 ,,	34 27	115 3	69	1·02589	Near Cape Leeuwin.
38	22 ,,	32 51	115 0	68	1·02592	,, Fremantle.
39	28 ,,	35 8	115 30	68	1·02604	
40	28 ,,	34 8	115 8	69	1·02607	,, Cape Leeuwin.
41	29 ,,	35 9	117 9	68	1·02609	
42	29 ,,	35 5	118 35	68	1·02612	
43	30 ,,	35 23	121 15	62	1·02587	Australian Bight.
44	30 ,,	35 19	123 40	62	1·02582	,, ,,
45	31 ,,	35 32	125 56	60	1·02570	,, ,,
46	31 ,,	35 25	128 35	60	1·02596	,, ,,
47	1 June	35 27	131 37	60	1·02576	,, ,,
48	1 ,,	35 30	134 28	61	1·02607	,, ,,
49	2 ,,	35 15	137 46	59	1·02656	Gulf of St. Vincent.
50	4 ,,	35 27	138 7	59	1·02717	,, ,,
51	4 ,,	37 28	139 44	58	1·02627	
52	5 ,,	38 35	142 0	59	1·02625	

Table A 2.—Densities of Waters obtained between Fremantle and Melbourne, August, 1896 :—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
115	31 July	35 19	134 46	60	1·02575	Australian Bight.
116	31 ,,	35 15	132 49	58	1·02579	,, ,,
117	1 Aug.	35 5	129 0	56	1·02587	,, ,,
118	1 ,,	35 8	126 46	56	1·02576	,, ,,
119	2 ,,	35 11	124 16	58	1·02579	,, ,,
120	2 ,,	35 8	121 42	56	1·02579	,, ,,
121	3 ,,	35 8	119 52	62	1·02596	
122	4 ,,	35 11	117 40	62	1·02588	
123	5 ,,	34 39	115 26	64	1·02582	Near Cape Leeuwin.
124	5 ,,	33 0	115 0	66	1·02581	Near Fremantle.
125	19 ,,	29 25	114 40	66	1·02576	West Coast of Australia.
126	21 ,,	30 16	114 45	66	1·02570	,, ,,
127	22 ,,	31 54	115 37	64	1·02593	,, ,,
128	22 ,,	32 25	115 15	65	1·02605	,, ,,
129	23 ,,	34 10	114 53	64	1·02588	Near Cape Leeuwin.
130	23 ,,	35 9	116 57	62	1·02573	
131	24 ,,	35 4	118 13	63	1·02570	
132	24 ,,	35 13	120 12	58	1·02598	Australian Bight.
133	25 ,,	35 29	123 3	58	1·02581	,, ,,
134	25 ,,	35 30	125 38	58	1·02564	,, ,,
135	26 ,,	35 34	128 14	56	1·02567	,, ,,
136	26 ,,	35 26	130 48	56	1.02552	,, ,,
137	27 ,,	35 25	133 0	56	1·02558	,, ,,
138	27 ,,	35 28	135 12	56	1·02564	,, ,,
139	28 ,,	35 23	137 4	56	1·02612	St. Vincent's Gulf.

Table A 3.—Densities of Waters obtained between Fremantle and Melbourne, November and December, 1896:—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
140	2 Nov.	35 16	124 13	56	1·02557	Australian Bight.
141	3 ,,	35 16	118 50	59	1·02573	
142	4 ,,	35 10	117 0	64	1·02598	
143	5 ,,	35 00	115 30	68	1·02585	
144	8 ,,	32 10	114 55	64	1·02570	
145	8 ,,	34 00	117 00	64	1·02570	Longitude in error; should be about 115°.
146	9 ,,	35 05	118 40	64	1·02573	
147	9 ,,	35 08	120 40	62	1·02551	Australian Bight.
148	10 ,,	35 10	123 40	61	1·02554	,, ,,
149	10 ,,	35 30	127 00	60	1·02548	,, ,,
150	11 ,,	35 39	129 10	59	1·02533	,, ,,
151	11 ,,	35 36	132 10	60	1·02537	,, ,,
152	12 ,,	35 33	134 50	60	1·02531	,, ,,
153	12 ,,	35 15	137 50	60	1·02631	St. Vincent's Gulf.
234	17 ,,	38 30	142 20	58	1·02549	
235	17 ,,	37 50	140 10	56	1·02536	
236	19 ,,	38 10	138 20	59	1·02571	
237	20 ,,	35 15	137 49	62	1·02580	St. Vincent's Gulf.
238	20 ,,	35 23	132 10	60	1·02555	Australian Bight.
239	21 ,,	35 20	130 56	58	1·02529	,, ,,
240	21 ,,	35 24	135 12	60	1·02574	,, ,,
241	22 ,,	35 20	127 02	60	1·02566	,, ,,
242	23 ,,	35 15	124 20	62	1·02580	,, ,,
243	23 ,,	35 10	121 37	60	1·02527	,, ,,
244	24 ,,	35 5	118 27	64	1·02552	
245	25 ,,	35 6	117 15	62	1·02527	
246	26 ,,	34 20	115 00	62	1·02548	Near Cape Leeuwin.
247	26 ,,	32 45	114 59	66	1·02544	
248	2 Dec.	33 36	114 35	62	1·02565	
249	5 ,,	35 28	127 43	61	1·02541	Australian Bight.
250	6 ,,	35 32	127 25	60	1·02537	,, ,,
251	6 ,,	35 28	130 20	60	1·02515	,, ,,
252	7 ,,	35 40	135 06	61	1·02542	,, ,,
253	7 ,,	35 15	137 30	63	1·02581	St. Vincent's Gulf.
254	8 ,,	35 32	138 09	64	1·02646	,, ,,
255	8 ,,	36 51	139 15	60	1·02527	
256	8 ,,	38 57	143 34	58	1·02519	
257	9 ,,	38 51	143 08	61	1·02539	

Table B 1.—Densities of Waters obtained between Melbourne and Brisbane, May and June, 1896 :—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
15	23 May	27 02	153 33	68	1·02595	Near Cape Moreton.
16	23 ,,	28 39	153 42	70	1·02607	
17	24 ,,	31 37	153 03	68	1·02601	
18	24 ,,	32 20	152 44	67	1·02596	
19	27 ,,	37 00	150 09	62	1·02588	
20	27 ,,	37 50	149 10	59	1·02601	
21	28 ,,	39 07	146 32	57	1·02570	
22	28 ,,	38 24	144 42	57	1·02570	Near Port Phillip.
25	28 ,,	27 00	153 33	72	1·02613	Near Cape Moreton.
26	31 ,,	30 55½	153 6½	71	1·02593	
27	3 June	37 34	149 55	60	1·02604	
28	4 ,,	38 30	144 53	58	1·02604	Near Port Phillip.
53	17 May	38 31	147 59	60	1·02604	Off 90-mile Beach.
54	18 ,,	36 51	150 25	62	1·02592	
55	21 ,,	28 47	153 40	73	1·02572	
64	6 June	27 26½	153 36	72	1·02585	Near Cape Moreton.
65	7 ,,	32 27½	152 39½	70	1·02590	
66	10 ,,	37 15½	150 05	65	1·02573	
67	11 ,,	38 25	147 58	59	1·02579	Off 90-mile Beach.

Table B 2.—Densities of Waters obtained between Melbourne and Brisbane :—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
107	15 Aug.	27 00	153 25	61	1·02598	Near Cape Moreton.
108	16 ,,	29 50	153 30	64	1·02598	
109	16 ,,	31 10	153 5	59	1·02598	
111	20 ,,	36 15	150 30	53	1·02598	
112	20 ,,	37 50	149 32	49	1·02571	
113	20 ,,	38 30	148 00	50	1·02589	
114	21 ,,	39 00	146 10	47	1·02597	Near Wilson's Promontory.

Table B 3.—Densities of Waters obtained between Melbourne and Brisbane, December, 1896 :—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
161	5 Dec.	27 31	153 32	77	1·02549	Near Cape Moreton.
162	6 ,,	31 15	153 15	76	1·02558	
163	6 ,,	32 45	152 15	69	1·02534	
164	9 ,,	37 50	149 30	62	1·02526	
165	10 ,,	39 00	145 50	62	1·02528	Near Wilson's Promontory.

Table B 4.—Densities of Waters obtained between Melbourne and Brisbane, March, April, and May, 1897 :—

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1897.	° ′	° ′	°		
226	13 Mar.	28 12	153 45	82	1·02541	Near Cape Byron.
227	14 ,,	33 15	151 50	80	1·02562	
228	17 ,,	35 10	150 55	78	1·02563	
229	17 ,,	37 15	150 10	78	1·02529	Near Cape Howe.
205	11 April	38 8	148 30	63	1·02532	Off 90-mile Beach.
206	11 ,,	36 30	150 20	66	1·02533	
207	14 ,,	31 30	153 00	71	1·02545	
208	14 ,,	28 54	153 40	72	1·02539	Near Cape Byron.
218	1 May	30 00	153 00	73	1·02547	
219	2 ,,	32 25	152 40	72	1·02538	
220	5 ,,	37 00	150 05	68	1·02540	
221	5 ,,	38 45	147 30	67	1·02530	Off 90-mile Beach.

Table C 1.—Densities of Waters obtained on the East Coast of Australia, North of Brisbane, May and June, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
6	16 May	15 30	145 20	76	1·02394	Near Cooktown.
7	16 ,,	16 45	145 50	74	1·02417	
8	17 ,,	18 20	146 20	74	1·02483	Off Hinchinbrook Isld.
9	18 ,,	19 20	147 15	71½	1·02473	
10	19 ,,	20 10	148 50	72	1·02390	
11	19 ,,	21 35	150 00	71	1·02518	
12	20 ,,	23 10	151 05	70	1·02599	Near Cape Capricorn.
13	20 ,,	24 00	152 30	74	1·02608	
14	21 ,,	26 11	153 27	72	1·02584	Near Cape Moreton.
23	23 ,,	15 30	145 30	75	1·02419	Near Cooktown.
24	27 ,,	23 00	152 00	72	1·02588	Near Cape Capricorn.
56	24 ,,	26 11	153 21	73·7	1·02594	Near Cape Moreton.
57	24 ,,	24 08	152 40	74	1·02601	
58	25 ,,	23 09	151 04	74	1·02592	Near Cape Capricorn.
59	26 ,,	21 09	149 18½	71	1·02412	
60	2 June	19 40½	147 26½	76	1·02493	Near Cape Upstart.
61	3 ,,	23 9	151 41	74	1·02610	Near Cape Capricorn.
62	3 ,,	24 8	152 40	73	1·02603	
63	4 ,,	26 13	153 28	73	1·02597	Near Cape Moreton.
89	— May	13 30	143 42	77	1·02476	Near Cooktown.
90	Days not given in return.	12 00	143 14	78	1·02441	Off Cape Greville.
91		10 45	142 38	80	1·02398	At Albany Pass.
92		10 36	141 55	80	1·02520	At Booby Island.
93		13 19	141 28	78	1·02412	In Gulf of Carpentaria.
94		15 39	140 56	78	1·02501	

Table C 2.—Densities of Waters obtained on the East Coast of Australia, North of Brisbane, August, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
96	8 Aug	15 40	145 23	71	1·02594	Near Cooktown.
98	9 ,,	17 06	146 02	69½	1·02502	
99	9 ,,	18 22	146 24	69½	1·02521	Off Hinchinbrook Isld.
100	11 ,,	19 46	148 07	68	1·02506	
101	11 ,,	20 30	149 01	66	1·02530	
102	11 ,,	21 14	149 23	64	1·02469	
103	12 ,,	22 49	151 00	63	1·02559	
104	12 ,,	23 51	152 05	66	1·02572	
105	13 ,,	25 40	153 25	70	1·02572	
106	13 ,,	26 46	153 25	68	1·02569	

Table C 3.—Density of Waters obtained on the East Coast of Australia, north of Brisbane, November and December, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
154	29 Nov.	17 34	146 07	80	1·02528	
155	29 ,,	19 05	146 45	81	1·02575	
156	30 ,,	19 05	147 10	82	1·02592	
157	1 Dec.	20 25	149 05	81	1·02558	
158	1 ,,	21 20	149 22	81	1·02531	
159	2 ,,	23 28	151 15	80	1·02601	Near Cape Capricorn.
160	2 ,,	24 05	152 35	79	1·02561	

Table C 4.—Densities of Waters obtained on the East Coast of Australia, north of Brisbane, March and April, 1897.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1897.	° ′	° ′	°		
222	2 Mar.	19 55	148 25	86	1·02516	
223	8 ,,	19 55	148 25	88	1·02252	
224	10 ,,	22 40	150 55	84	1·02537	
225	11 ,,	26 13	153 28	80	1·02535	
209	17 April	26 45	153 23	76	1·02550	
210	18 ,,	24 30	153 23	77	1·02546	
211	19 ,,	21 25	149 55	79	1·02576	
212	19 ,,	20 10	148 50	80	1·02543	
213	20 ,,	19 12	147 20	80	1·02546	
214	24 ,,	16 30	145 35	80	1·02510	
215	26 ,,	19 12	147 20	79	1·02541	
216	27 ,,	21 25	149 55	79	1·02574	
217	28 ,,	24 30	153 23	77	1·02543	

Table D 1.—Densities of Waters obtained between Melbourne and The Bluff, New Zealand, May and June, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
88	23 June	38 31	144 51	57	1·02612	
68	17 May	40 24½	147 41½	61	1·02561	
69	17 ,,	42 20	148 24	56½	1·02528	
70	18 ,,	43 20	148 09	58	1·02584	
71	19 ,,	44 04	152 00	55	1·02573	
72	19 ,,	44 38	155 15	55	1·02576	
73	20 ,,	45 19	158 39	54	1·02531	
74	20 ,,	45 53	162 19	53·5	1·02528	
75	21 ,,	46 16	165 46	56·5	1·02545	

Table D 2.—Densities of Waters obtained between Melbourne and Bluff, November, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
166	18 Nov.	38 33	144 51	60	1·02543	
167	19 ,,	40 00	147 03	59	1·02511	
168	19 ,,	42 13	148 29	57	1·02512	
169	20 ,,	43 18	148 01	56	1·02484	
170	21 ,,	43 53	151 08	53	1·02474	
171	21 ,,	44 29	154 41	54	1·02474	
172	22 ,,	45 04	158 03	52	1·02480	
173	22 ,,	45 26	160 19	52	1·02473	
174	22 ,,	45 32	160 54	52	1·02486	
175	22 ,,	45 38	161 30	52	1·02480	
176	22 ,,	45 44	162 06	52	1·02483	
177	22 ,,	45 49	162 38	52½	1·02497	
178	23 ,,	45 54	163 10	53	1·02478	
179	23 ,,	46 00	163 45	53	1·02497	
180	23 ,,	46 06	164 20	53	1·02465	
181	23 ,,	46 11	164 55	53½	1·02472	
182	23 ,,	46 17	165 30	54	1·02460	
183	23 ,,	46 23	166 09	53	1·02454	
184	23 ,,	46 45	167 35	53	1·02474	
185	23 ,,	46 39	168 08	54½	1·02435	

Table E 1.—Densities of Waters obtained between Bluff, New Zealand, and Sydney, *via* Cook Straits, May, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
76	22 May	46 43	168 51	53½	1·02486	Near Bluff Harbour.
77	24 ,,	45 26	170 59½	52	1·02514	
78	26 ,,	43 55	173 04	52½	1·02470	
79	27 ,,	41 47	174 26	52½	1·02495	Cook Strait.
80	28 ,,	39 56	171 37	60	1·02523	
81	28 ,,	39 01	168 33	60	1·02575	
82	29 ,,	38 08	165 37	61	1·02621	
83	29 ,,	37 11	162 30	63	1·02548	
84	30 ,,	36 14	159 25	65	1·02536	
85	30 ,,	35 18	156 29	67	1·02613	
86	31 ,,	34 18	153 36	70	1·02612	
87	6 June	33 51	151 20	68	1·02604	Near Sydney.

Table E 2.—Densities of Waters obtained between Bluff, New Zealand, and Sydney, *via* Cook Straits, November and December, 1896.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.
	1896.	° ′	° ′	°		
186	24 Nov.	46 43	168 51	54	1·02418	Near Bluff Harbour.
187	25 ,,	45 55	170 48	52½	1·02459	
188	26 ,,	45 31	171 05	52	1·02459	
189	27 ,,	43 56	173 04	53	1·02459	
190	28 ,,	41 47	174 27	55½	1·02466	Cook Strait.
191	29 ,,	40 37	174 03	58	1·02489	,, ,,
192	29 ,,	40 15	172 39	58	1·02473	
193	29 ,,	39 21	169 46	60	1·02511	
194	30 ,,	38 26	166 48	61½	1·02534	
195	30 ,,	37 32	163 58	61	1·02522	
196	1 Dec.	36 36	160 55	65	1·02549	
197	1 ,,	36 00	158 34	65	1·02542	
198	2 ,,	35 31	156 52	69	1·02556	Weather very hot. Wind northerly.
199	2 ,,	35 05	155 01	70	1·02528	
200	2 ,,	34 28	153 05	71	1·02558	
201	3 ,,	33 52	151 23	67	1·02529	Southerly set changed inshore to northerly, hence change in temperature. Near Sydney.

Table F.—Densities of Waters obtained on Sorrento Back Beach, Bass Strait.

General Number.	Date when obtained.	Latitude S.	Longitude E.	Sea temperature, Fahr.	Density of Sample.	Remarks.	
	1896.	° ′	° ′	°			
A	28 Feb.	38 22½	144 46	64·2	1·02632	Note.—Readings A to M inclusive depend upon one reading of the small hydrometer only.	
C	7 Mar.	38 22½	144 46	66·1	1·02627		
D	13 ,,	38 22½	144 46	66·0	1·02605		
E	14 ,,	38 22½	144 46	66·0	1·02605		
F	20 ,,	38 22½	144 46	64·2	1·02623		
G	21 ,,	38 22½	144 46	64·2	1·02605		
H	27 ,,	38 22½	144 46	64·0	1·02596		
I	28 ,,	38 22½	144 46	64·0	1·02614		
J	3 Apr.	38 22½	144 46	64·0	1·02614		
K	4 ,,	38 22½	144 46	63·0	1·02623		
L	5 ,,	38 22½	144 46	62·5	1·02641		
M	6 ,,	38 22½	144 46	61·5	1·02623		
	1897.						
202	3 Feb.	38 22½	144 46	65·5	1·02596		
203	7 ,,	38 22½	144 46	63·5	1·02588		
204	8 ,,	38 22½	144 46	65·0	1·02591		°
258	8 Dec.	38 22½	144 46	63·0	1·02548	Max. air temp.	67·0
259	13 ,,	38 22½	144 46	64·0	1·02565	,,	67.8
260	14 ,,	38 22½	144 46	64·0	1·02553	,,	70·5
261	15 ,,	38 22½	144 46	65·0	1·02545		
262	18 ,,	38 22½	144 46	65·5	1·02573		
263	23 ,,	38 22½	144 46	64·5	1·02574	Max. air temp.	67·5
264	24 ,,	38 22½	144 46	65·0	1·02549	,,	69·5
265	25 ,,	38 22½	144 46	65·5	1·02548	,,	68·8
266	26 ,,	38 22½	144 46	66·7	1·02523	,,	84·2
267	28 ,,	38 22½	144 46	66·5	1·02538	,,	76·0
268	29 ,,	38 22½	144 46	66·5	1·02520	,,	86·6
269	31 ,,	38 22½	144 46	67·8	1·02543	,,	95·0
	1898.						
270	1 Jan.	38 22½	144 46	65·8	1·02546	,,	72·2
271	2 ,,	38 22½	144 46	66·0	1·02559	,,	72·8

Table G.—Observed Temperatures of Sea-water at Sorrento Back Beach, Bass Strait. Latitude, 38° 22½′ S.; longitude, 144° 46′ E.

Dates.	Number of Observations.	Maximum.	Minimum.	Mean.
		°	°	°
1895.				
1–14 February	2	67·0	66·0	66·5
1–15 April	3	64·0	63·0	63·3
1–15 November ...	4	61·0	59·8	60·3
1896.				
1–15 January	11	68·0	64·3	66·1
16–31 ,, ...	12	68·0	66·0	66.6
1–14 February	12	68·0	64·5	66·4
15–29 ,, ...	15	68·0	62·5	65·5
1–15 March	15	67·0	64·0	65·6
16–31 ,, ...	15	67·0	62·0	64·3
1–15 April	7	64·0	61·5	62·7
1–15 November ...	6	60·0	58·5	59·0
16–30 ,, ...	4	64·0	63·0	63·5
1–15 December ...	3	66·0	65·5	65·7
16–30 ,, ...	8	66·0	64·2	65·8
1897.				
1–15 January	12	66·5	63·2	65·4
16–31 ,, ...	10	66·3	63·7	65·0
1–14 February	9	67·5	63·5	65·4
15–28 ,, ...	3	66·8	66·2	66·5
1–15 March	2	65·0	64·7	64·9
16–31 ,, ...	1	......	......	61·8
15-31 October	1	......	......	57·8
1–15 November ...	7	61·0	58·0	59·7
16–30 ,, ...	8	62·5	59·8	61·2
1–15 December......	6	65·0	62·0	63·6
16–31 ,, ...	14	67·7	64·5	66·1

No. 5.—THE DETERMINATION OF HEIGHTS BY BAROMETRIC METHODS.

By Thomas Walker Fowler, M.C.E., F.R.G.S., F.G.S.

(*Read, Wednesday, January* 12, 1898.)

The geographer, surveyor, or civil engineer frequently requires to ascertain the relative heights of various points upon the earth's surface or their absolute heights above sea-level. The most accurate method of making such determinations is that termed by geodesists "precise levelling," being a method somewhat similar to that adopted by civil engineers for determining the relative heights of points close together, and known as "spirit levelling." Work of this character is, however, both tedious and expensive, and is but rarely resorted to, more especially when the points to be connected are a considerable distance apart, or separated by obstacles, such as dense forests or precipitous mountains. In such cases even the civil engineer's "spirit levelling" becomes very costly, and, for preliminary investigations, has to be abandoned.

Two other systems remain, one by ascertaining the atmospheric pressure at the different places whose altitudes are required, and from such pressures deducing the heights, the other by measuring the angles of elevation or depression which the objects subtend from each other or from other points at which such objects are visible. The first method is that generally termed "barometric levelling" and the second "trigonometric levelling." The writer has for several years, when opportunity offered, made experiments with both methods, and he hopes that the results of his barometric experience may be useful to others.

Under the head of "barometric levelling" it will be well to consider—1st, the instruments used; 2nd, the methods of taking the observations; and 3rd, the methods of computing the results. The instruments used are necessarily some description of barometer, supplemented by thermometers, for the purpose of ascertaining the air temperature. The barometer may be one of several types, mercurial, aneroid, or boiling-point thermometer. For mountain work the mercurial barometer is generally of either the siphon or the Fortin type, most of the writer's work (so far as mercurials are concerned) having been done with the former.

The great advantage claimed for the siphon barometer is that as the diameters of the tube at the upper and lower limbs are the same the capillary depressions in the two limbs would be equal,

and consequently they neutralise each other. The writer's experience does not support this view completely. The meniscus at either end is formed under different circumstances; if the mercury has been rising in the one it has necessarily been falling in the other, and examination will at once show that the shape of the meniscus, and presumably the amount of the depression, differs considerably under these circumstances. The writer finds that siphon mountain mercurials (which, to be portable, are necessarily of small bore) require vigorous tapping. Further, when the instrument is inverted and ready for travelling the (normally) lower limb is free from mercury, whilst, when in use, the mercury will run up that limb to an extent depending upon the atmospheric pressure. Hence this portion of the mercury is brought successively in contact with a very large area of tube in proportion to its mass, and it speedily becomes more or less foul when in use. The advantage possessed by the siphon over the Fortin mercurial for mountain work, in the writer's opinion, is that owing to the absence of the cistern at the bottom the volume of mercury required and consequently the weight of the instrument is very much reduced. Latterly the writer has been using a Fortin mountain mercurial, in addition to the siphon ones, and so far as his experience goes he decidedly prefers it. In mounting the instruments prior to reading it is of course essential to have them perfectly vertical, and, in the writer's opinion, made fast at both top and bottom. Sufficient steadiness cannot be obtained by supporting the instrument in gimbals, as is frequently done, or by suspending them from the top only. The writer's system of plumbing a Fortin barometer is as follows:—Having suspended the instrument and made it fast at the bottom, set the mercury to touch the fiducial point, then rotate the instrument through 180 degrees on its vertical axis. If the setting is still perfect the instrument is perpendicular in the vertical plane passing through the centre of the tube and the fiducial point. If not, alter the bottom clamping screws until the above adjustment remains correct on rotation through 180 degrees. Then rotate through 90 degrees and adjust in plane perpendicular to the first. Care must be taken in erecting the instruments to place them so that the sun will not shine on them when in use, as otherwise the temperature of the mercury in the tube will probably differ from that of the attached thermometer. It is scarcely necessary to say that they must always be inverted prior to being carried. If a siphon barometer it should always be inverted or restored to the normal position with the short limb *upwards*, otherwise air is certain to get in the tube. If a Fortin, the mercury should be caused to fill the cistern (by using the adjusting-screw) prior to inversion. Mercurial barometers require most careful carrying. When carried in a vehicle

the lower end should rest on a soft cushion or bundle of blankets, whilst, if carried on horseback, they should be on the rider's back, and the horse should not be permitted to go out of a walk. The writer always feels safest with them when he is on foot with the barometers strapped across his back. The bearer of the instruments should, of course, be very sure-footed, as, if he fall, the barometers are certain to be ruined.

Aneroid barometers have the advantage of being much more portable than mercurials though, of course, they are less reliable. The writer finds that the arrangement [suggested by Admiral Wharton] of having a small disc placed at the end of the hand and perpendicular to the dial of the instrument useful in reducing parallax error in readings. Care should be taken to always hold the instrument in the same position in reading and to gently tap it, thus eliminating instrumental friction. It is advisable to keep the instrument in the shade as much as possible when in use. The verification of an aneroid barometer is a most important point and should be very carefully done. The testing-chamber used by the writer at the Melbourne University is arranged so that the instrument can be gently tapped prior to reading whilst being tested, thus the *testing* conditions are similar to the *using* conditions. The "recovery" test is an important one which the writer applies by exhausting the air-chamber as far as possible and restoring full atmospheric pressure again, in about two minutes. This is repeated six times, and the variation in the correction at full atmospheric pressure is noted. The writer has, through the kindness of Professor Kernot, experimented with an aneroid of the "Goldschmid" type in which the ordinary mechanical magnification has been replaced by optical magnification, but has not found any advantage therefrom, whilst the difficulty of verifying the instrument is greatly increased.

The boiling-point thermometers used by the writer were made by J. Hicks, London, and have proved most satisfactory instruments. During construction they were subjected to his method of fixing the zero, and no trouble has been experienced from change of zero whilst in use, though some of the instruments were made three years ago. The instruments have an extremely open scale (about 1 inch to the degree Fahr.), and are graduated to 0·05°, so that they can be readily read to 0·01° Fahr., which corresponds to about 0·006 of an inch of mercury. During a series of some thirty readings taken with each instrument on Mount Juliet in December, 1896 (extending over five days), a pair of boiling-point thermometers proved to be slightly more sensitive and accurate than two siphon mercurial barometers used on the same expedition. The great difficulty in connection with the boiling-point apparatus is the verification of the thermometers, and a method with which the writer is experimenting bids fair to overcome this. Immersed

in steam the reading of the thermometer can be ascertained with the greatest ease to 0·01° Fahr., but if placed in the ordinary water-bath for comparison with other thermometers the writer has been unable to get a steady reading no matter how vigorously the stirring operations are carried on. Further, when compared in the water-bath at (say) 200° Fahr., the thermometer being vertical, its bulb is subject to a considerably greater pressure than it would be if immersed in steam at the same temperature, and consequently the thermometer reading may be expected to be somewhat higher. The apparatus with which the writer is experimenting consists of a boiling-point apparatus with air and steam tight joints, and glass tube as a thermometer chamber, the whole being connected with a water-jet exhaust, and the barometer of the aneroid testing chamber. The supply of steam can be regulated by control of the gas-jet heating the apparatus, while the exhaust can also be readily adjusted so that there is no difficulty in getting absolutely steady thermometer and barometer readings, and hence determining the pressure of the steam corresponding to a given reading of the thermometer. It is of course unnecessary for the present purpose to know what the absolute temperature of the steam is, and indeed it would seem desirable to graduate thermometers used for determining heights by the boiling point of water, not in degrees Fahr., or cent., but in inches or millimetres of mercury.

The apparatus in which the thermometer is placed when in use consists of a boiler to which a jacketed-tube (of length sufficient to contain the whole of the thermometer) is attached. A light wire carrier is placed in the tube, and prevents the bulb of the thermometer touching the sides of the jacketed-tube. A vent-tube placed near the top of the tube discharges the steam at one side, the thermometer passing through an india-rubber washer at the top. In use the thermometer is inserted as far as possible in the jacketed-tube, so that stem and bulb shall be at the same temperature, and about half an inch of the mercury column alone need be visible. The bulb of the thermometer should be about 4 inches (as a minimum) above the water in the boiler so as to be fairly free from the splash of the water when boiling. The spirit-lamps burning vaporised spirit seem the most suitable for use with the apparatus in the field, though if care be used the ordinary camp fire may be used. The heat and flame must be applied to the boiler alone, however, and not allowed to reach the sides of the steam jacket, or a broken thermometer will probably be the result.

The use of maximum thermometers has been suggested for taking boiling-point observations, but the writer considers them unsuitable for the purpose in view of the alteration in the reading due to variations in the temperature of the stem (*vide* note by

writer in Quarterly Journal of the Royal Meteorological Society vol. 23, page 305). Boiling-point thermometers are, of course, fragile instruments, and require more care in transport than an aneroid barometer, though much less than a mercurial. On one of the writer's expeditions a bundle of blankets in which the thermometers packed tumbled down the side of a mountain for some 30 feet without injuring the instruments. A further advantage with the thermometer is that if injured it discloses the fact at once; whilst unbroken it is trustworthy, when broken it refuses to give any indication. On the contrary, a mercurial barometer with air in tube, or an aneroid barometer, the index of which has been deranged by a severe fall, will continue to give some readings and not of itself disclose the injury.

But little need be said as to the methods of taking observations save that for accurate work simultaneous readings at upper and lower stations are essential. The writer does not believe in the system of reading the aneroid in the morning prior to leaving home, taking readings at different places during the day, again reading the aneroid on returning home at night, and expecting accurate determinations of the altitudes of the stations visited from such observations. In settled weather the ordinary atmospheric tides alone are sufficient to introduce most serious discrepancies, whilst in unsettled weather irregular fluctuations of pressure will upset the results. Care must be taken to observe the air temperature *in the shade*, and if the humidity formulæ are used in the computations the temperature of the wet bulb must also be noted. With reference to the use of the boiling-point apparatus fresh water should be used for each observation, as if this be not done the percentage of impurities in the water becomes increased as portions of it are evaporated, and the boiling point is altered in consequence. The writer has not in his work experienced any difficulty in obtaining water of sufficient purity, and it should be remembered that water of uniform quality and not necessarily of *absolute* purity is required. For determining with fair accuracy the height of a point situated (say) 30 or 40 miles from the base station, the writer considers that at least six or seven sets of simultaneous observations should be taken at (say) hourly intervals. Should the readings at each station remain fairly constant the work may be considered reasonably trustworthy, but should the barometers be rapidly altering accurate results cannot be expected. In such a case the work should be postponed till a more suitable occasion.

As to computing the results from the observations we are practically reduced to the adoption of a formula of one of two types, the first that in which the air is assumed to be of an average moisture throughout, and the other in which the actual amount of moisture at each station is observed and used in the computations.

Of the former the Laplace formula is the most celebrated, and probably as reliable as any of the modifications suggested by subsequent authorities, whilst of the latter the one deduced by Professor Ferrel and set forth in the United States Coast and Geodetic Survey Report of 1881, may be taken as perhaps the most convenient and reliable. Reference may also be made to Lieut. Rennie's paper in Trans. Royal Inst. Academy, vol. 23, part 2. The writer has taken many observations for the purpose of testing these formulæ against each other, and he generally finds that the "probable error" as deduced by the method of least squares is about two-thirds as great with the Ferrel formula as with the Laplace. At the same time he finds that the Ferrel formula gives generally results about one-part in two hundred greater than those obtained from the Laplace one. This difference is caused by Ferrel using a slightly larger constant as the first term in his formula than Laplace (60,521·5 instead of 60,158·6). In cases where the writer has been able to check his results by actual "spirit levelling" as practised by civil engineers, he has found his Laplace means nearer than his Ferrel ones. He therefore considers that the Ferrel formula with the Laplace constant restored would probably give the most accurate and consistent results. As the Ferrel formula is not often quoted by writers on barometric levelling the writer's modification of it is given as an appendix to this paper. In reducing observations the barometric grade should always be ascertained and allowed for if possible. The writer always makes this correction in his work after a careful inspection of the isobaric charts prepared at the Melbourne Observatory for the period covered by his observations.

The following series of heights deduced for a mountain, on one trip, will show what may be done. The observations were made with a siphon barometer, and at the time the writer considered the results decidedly inferior. The observations were taken on one day at hourly intervals. Computed heights, 2,068·5 feet, 2,070·1 ft., 2,078·2 ft., 2,081·9 ft., 2,090·8 ft. and 2,076·2 ft. Mean result, 2,077·6 ft. Max. differences from mean + 13·2 ft. and — 9·1 ft.

As the result of the writer's experience, it may be said that really reliable determinations of height (well within one per cent. of the truth, where the difference in height is considerable) may be made with mercurial barometers, that with the boiling-point apparatus an accuracy not very much inferior to that of the mercurial barometers can be attained, whilst with aneroids, if frequently checked, either with mercurials or the boiling point apparatus, very valuable results may be obtained. Without such checks, however, they become unreliable.

APPENDIX.

Barometric Levelling Formula.

Mercurial Barometer, with Brass Scale.

	At Lower Station.	At Upper Station.
Observed height of barometer	H_o	h_o
,, temperature of mercury	T	T'
,, ,, of air (dry bulb)	t	t'
,, ,, of wet bulb	t_w	t'_w
Height of mercury reduced to 32° Fahr.	H_r	h_r
Vapour tension of saturation at temperature of wet bulb	b	b'

Altitude of lower station above sea-level = S

Mean latitude of stations ... ... = L

Earth's radius in feet = r = 20,890,000 approximately.

Difference of elevation of stations in feet = Z

$$H_r = H_o \left\{ 1 - 0{\cdot}000\ 089\ 6(T - 32^\circ) \right\}$$

$$h_r = h_o \left\{ 1 - 0{\cdot}000\ 089\ 6(T' - 32^\circ) \right\}$$

$$Z = 60{,}159 \log \frac{H_r}{h_r} \times \left\{ \begin{array}{l} \left\{ 1 + 0{\cdot}001\ 017\ (t + t' - 64) \right\} \left(1 + 0{\cdot}189\ \frac{b}{H_r}\right) \left(1 + 0{\cdot}189\ \frac{b}{h_r}\right) \\ \left\{ 1 - 0{\cdot}000\ 084\ (t - t_w) \right\} \left\{ 1 - 0{\cdot}000\ 084\ (t' - t'_w) \right\} \\ \left(1 + \frac{2S}{r}\right) \left(1 + \frac{Z}{r}\right)\ 1 + 0{\cdot}002\ 606 \cos 2\ L \end{array} \right\}$$

For tables facilitating use of this formula see U.S. Coast and Geodetic Survey Report, 1881.

No. 6.—ANTARCTIC AND SOUTHERN EXPLORATION.

By the Hon. P. G. King, M.L.C., F.R.G.S.

(*Read Wednesday, January* 12, 1898.)

[*Abstract.*]

Since Dr. Nansen's return in safety from his attempt to reach the North Pole, by means of what Sir William Hooker described as a "wide departure from any plan which had been put in practice for the purpose of Polar discovery," the attention of the scientific world has been directed to what may prove to be the more accessible fields of the Antarctic Circle, as evidenced by the conclusion arrived at during the meeting of the Anglo-Australasian Conference which was held at London in July last in the presence of all the Colonial Premiers.

Sir Clements Markham, the President of the Royal Geographical Society, with a number of distinguished fellow-members, has been, and still is, advocating the equipment of an expedition towards the South Pole for the purposes of scientific geographical research; such expedition to have especially in view the important object of closely noting the phenomena of terrestrial magnetism. This duty was entrusted to Captain James Ross, R.N., in 1841. Yet, notwithstanding the valuable results then obtained by that commander, and by others since that time, there still remains a wide field for further investigation.

It will be remembered that Humboldt, in 1828, established a small magnetic observatory at Berlin, and concerted with it far and near able observers of the magnetic variation. Humboldt was thus the first to open the way to our modern knowledge of terrestrial magnetism. He was followed by Professor C. F. Gauss and William Weber, who, with an observatory at Göttingen, joined in the general work; they furnished descriptions of their instruments and published a valuable treatise upon them.

The subject of southern exploration can never be approached without bestowing a thought upon the adventurous seamen who in former years, fought their way into the untraversed southern high latitudes. First on the list stands Captain Cook, who, in 1774, in his small vessel, reached the latitude of 71° S. Next is the somewhat forgotten name of James Weddell, a master in the Royal Navy, who, in a private expedition, in the "Jane," a brig of 160 tons, with a consort cutter of 65 tons, passed Cook's limit, reaching to the parallel of 74° 15′.

Enderbys' whaling-ships, with Balleny, Bellinghausen, Biscoe, and Lieutenant Wilkes of the United States Navy, followed in 1839–40.

Her Majesty's ships "Erebus" and "Terror," under the command of Sir James Clarke Ross, R.N., who discovered the north magnetic pole, visited this region in 1841–42. He discovered and named many important points, such as Cape Adair on the mainland, Possession Island, and others, also the volcanic mountains.

The voyage of H.M.S. "Challenger," in 1874, under the command of Sir G. Nares, R.N., must not be overlooked, though Sir George did not pass beyond the northern boundary of the South Frigid Zone, in longitude 78° E. The lowest temperature registered on this occasion by Lord George Gordon was 22° Fahr.

It will be remembered that the early search for a southern continent originated in the supposition that the great extent of dry land in the Northern Hemisphere required a similar area in the southern, so as to constitute a counterbalancing weight and thus preserve the equilibrium of the globe. Cook and others dispelled the idea generally, but Sir James Ross discovered an extent of connected land to warrant the belief that southward of his "South Victoria," and eastward and westward of it, there was an area of ice and snow capped land sufficient to satisfy the assertions of those who believed in the necessity of a balancing weight.

But whether it is necessary or not that such a continent, or more than a continent, once existed, there is now little doubt from the evidence given by animal and vegetable life that it did exist; the same genera and species occur in such now widely-separated lands as South Africa, South America, Australia, and New Zealand. Professor Huxley was so satisfied with this that he has even given to such an extensive range of supposed dry land as would be required to connect those parts, the appropriate name of Notogea.

The Admiralty does not, at present, hold out any promise of assistance with ships, officers, or men, but Parliament would probably supplement any private contributions with material aid.

On the colonies immediately interested great expectations are formed, though none of the Colonial Premiers at the Conference alluded to gave much encouragement.

It is not to be supposed that there will be any difficulty in finding a reliable and competent leader to take charge of such a venture, or of finding a crew well versed in the various necessary branches of science. The leader need not expect to go through all the hardships and risks that were encountered by Fridtjof Nansen, but he must be prepared to push his way beyond where his ship or steamer may be able to reach. A captive balloon could only be used from the ship to show where he might go to beyond her

For all useful purposes it is not necessary that the explorers should waste much time in trying to reach the earth's axis, a mere mathematical point; it would be sufficient for all scientific purposes that an approach to it should be made within three or four degrees of latitude.

It is curious to reflect what would be the experience of those, if any, who should happen to reach this mathematical point, the actual position of which could only be determined by an altitude of the sun, giving as its zenith distance the complement of 90° of its declination for its latitude. The sun itself from such a point could have no change in altitude except such as was daily caused by increase or decrease of its declination or motion on the ecliptic, coupled with its motion in right ascension. As for "time," the explorers would have to make their own, being unable to obtain an hour angle from any of the heavenly bodies; they could get no apparent time, but they might get an approximate time by observing a lunar distance and getting Greenwich time from a nautical almanac. Having thus obtained Greenwich time, it would thenceforth be their time, and the meridian of Greenwich could be determined as their starting-point. Longitude, they could have none, being at the convergence of all the meridians. Standing at the South Pole their only line of vision would be northerly along a north meridian line.

I may, perhaps, remind you that the so-called N. end of the needle is also termed the "marked" end of the needle or North-seeking Pole, and in France the north-seeking end is termed the Austral or Southern Pole, and the south-seeking end the Boreal or Northern Pole.

It is interesting to read Sir J. C. Ross's accounts of his magnetical observations. The fixing of the site of the south magnetic pole would naturally be the leader's ambition.

Various positions have been assigned to it. Duperry, the French navigator, in 1825, had, several times, crossed and recrossed the magnetic equator, and from observations of variation and dip, had calculated its position. Professor Gauss, in his study at Göttingen, had also assigned a position, but no one quite agreed with Sir James Ross's observations. His approach to it is graphically described in the account of his voyages.

"We were in latitude 76° 12′ S. longitude 164° E.; the magnetic dip 88° 40′, and the variation 109° 24′ E. We were, therefore, only 160 miles from the Pole. It was painfully vexatious to behold at an easily accessible distance, under other circumstances, the range of mountains in which the Pole is placed. I felt myself, however, compelled to abandon the perhaps too ambitious hope, that I might plant the flag of my country on both the magnetic poles of our globe."

In his report of his discovery of the north magnetic pole in 1831, he says, "The north end of the horizontal needle pointed north 57° W.; magnetic dip had increased to 89° 41′ N.; these observations enabled me to determine which way we should proceed, and the distance that lay between us and the great object we had in view." On the 1st June, 1831, he camped in latitude 70° 5′ 57″ N. and longitude 96° 46′ 45″ W., the dip was 89° 59′, or within one minute of the vertical, the horizontal needles being perfectly inactive.

Deep-sea soundings will occupy much attention, and it will be curious to find that great depressions in the ocean-bottom are found in connection with such volcanic action as must from time to time, occur in the vicinity of such volcanoes as Mount Erebus, of 12,000 feet elevation, and Mount Terror of 7,000 feet.

Whenever the proposed expedition from England is fitted out, and gets away upon its field of operation, the greatest interest in it will be taken by all the Australasian Colonies, not from any expected commercial advantages so much to be gained as from an earnest regret that the South Polar or Antarctic Circle should exhibit so large a blank, in a geographical point of view, as it does.

No. 7.—THE DISCOVERY OF NEW GUINEA BY ANTONIO DE ABREU.

By J. R. McClymont, M.A.

(*Read Wednesday, January* 12, 1898.)

The various methods of teaching and of studying geography may be described as—Pictorial, Descriptive, or Historical.

The Pictorial method is that which teaches by means of maps—more or less highly conventionalised representations of the surface and outlines of the earth. Many early maps, between the twelfth and the sixteenth centuries, were mere mnemonic diagrams. A circle with a few radii represented the distribution of land and water. Sometimes the zones were named, at other times the known continents. Then the outlines of the known continents were drawn, more or less vaguely. Contemporaneously with these mappemondes there appear, in the fourteenth century, portulani, or hydrographic charts of a high degree of excellence, called forth by the requirements of an extending commerce. These are principally charts of the Mediterranean, and amongst them those of Pietro Vicente, 1311, and of Dulcert, 1339, already presage the highest attainments of modern hydrography.

One objection to maps is that they afford to the theorist a ready means of illustrating his pet theories, and this fact has been largely taken advantage of in all times. Islands, and even continental land of great extent, have been represented on maps of quite recent date, although these have no existence. Thus the islands Dina and Marsevin appear on maps in use at the present day, and an Antarctic continent is pourtrayed upon some of them with as great definiteness of outline as is given to Africa or to Australia. There exists also a tendency to convert a map into a mere index of place-names without the advantage, which an index possesses, of alphabetical arrangement.

It is only fair to add that the construction of maps in relief does much to remove the objection on the score of conventionality. A relief map constructed, without distortion, upon a natural scale would be, perhaps, the highest achievement of the Pictorial system.

A method of teaching geography in which a portion of the earth's surface is used as if it were a relief map, and from that portion the whole explained—such a method is a development of the Pictorial. Instead of teaching from a picture, the pupil, by this method, is taken out of doors and taught directly from Nature the facts of geography, and if desired, of physiography also. Whatever can be said in favour of bringing the pupil in actual contact with the subject-matter of his studies may be said in favour of this method,—the logical extension of which would be teaching by means of foreign travel. Unfortunately, the difficulties and the expense attendant upon travelling effectually prevent its general adoption, and I do not suppose such a method is ever practised preceptorially except on a very limited scale, and then chiefly in connection with archæology and hagiology.

The method of foreign travel being impracticable, its place is supplied by the second principal method, namely, the Descriptive, which is generally used in association with the Pictorial. Every book of travels is an aid to the Descriptive system of teaching. Such books, if they happen to be of ancient date, are commonly supposed to come within the domain of historical geography. They do come within its domain as materials for the historical geographer to work with, but they are not historical geography properly so called, for that implies the critical comparison of such materials, and cannot exist as a complete system until every portion of the earth has been scientifically explored, and every extant geographical monument of the past has been elucidated.

The third method,—the Historical—is one of private study, rather than of public tuition, although I can conceive of its being adapted to public tuition in conjunction with the other methods. This method, I venture to think, impresses the facts upon our mind in a more forcible way than any other practicable method.

For it aims at acquiring a knowledge of the whole history of the discovery of the earth by civilised man, and so has an educational thoroughness about it which cannot be surpassed. To know the coast-lines, say of South America, as they appeared to successive geographers, from Columbus onwards, will be to know them much more thoroughly than if I had received them into my mind as a finished product, and I will be possessed of the whole process, by means of which that product has been evolved. This is to watch the manufacture of a porcelain vase from the clay through all the processes of moulding, painting, and firing. The other plan is to look at it when it is finished and exposed in the show-room. The historical method links the study of the earth with the study of man, not only as a living entity, but also as a sentient being. There is no human feeling, no aim, nor aspiration that has not been awakened for good or for evil in the course of geographical discovery. The study of it reveals the plans, the antagonism, and the alliances of nations.

I shall now give you an example of the use of the historical method, as applied to South-western New Guinea and Prince Frederick Hendrick Island—the cradle of Australasian discovery. Time will only permit me to deal with the earliest period of its history, that namely, in which the Portuguese, under Albuquerque, having taken Malacca, after an arduous investment, despatched three vessels in November or December, 1511, to explore the Eastern Archipelago, and to open up a trade with the islands. A native junk, commanded by a Malay named by Barros Nehoda Ishmael, either preceded or accompanied the other vessels in order to inform the islanders that Malacca was in the hands of the Portuguese, and that they would find a market there for their wares. Antonio de Abreu, in the *Santa Caterina*, was placed in command of the entire expedition, with Francisco Serrão, and Simão Affonso Bisagudo, in command of the two accompanying vessels. There is an account of this voyage in the "Discoveries of the World," by Antonio Galvano, who was captain or governor of the Moluccas, from 1537 to 1540. When he wrote his treatise he was living in great neglect and poverty in a hospital in Lisbon, and the manuscript was bequeathed to his friend Francisco de Sousa Tavares, by whom it was published in 1563, six years after the death of the author. Some of the information which it contained relative to voyages to the Moluccas was gathered directly from those who had taken part in them. This was the case, for example, with respect to the voyage of Alvarado, in 1537, and that of the survivors of the vessel commanded by Hernão de Grijalva. Galvano, who had spent his days, and also his private fortune, in the service of John III, in the East, and who had refrained from amassing wealth for himself as seems to have been the practice of most of the Portuguese

officials in the East at that time,—Galvano was coldly received by his sovereign, and was refused the moderate pension for which he petitioned. Being thus in antagonism with the authorities governing Indian affairs he was not under any official restraint, and he records discoveries in his book which are not recorded by the official historians of his time, because to record them was to place information at the disposal of Spain, which might have been taken advantage of to the detriment of Portuguese conquest and commerce.

It appears, then, from the narrative of Galvano, that Abreu, on leaving Malacca, steered a south-easterly course across the main strait, and then passed through the strait of Saban. "Salat" is the Malay word in general use for "strait"; so the Portuguese called all the islands which they left on the port side "Los islas dos salites,"—the Straits Islands. Upon issuing from this strait, Abreu directed his course towards Java, and ran eastwards along its north coast as far as Agaçai, which Valentijn identifies with Gresik, near Sourabaya. *Oud en nieuw Oost-Indien, Deel II; Moluksche Zaken, Hoofdstuk ii.* There he shipped Malay and Javanese pilots, and, passing thence through the Strait of Madura, continued along the north side of the Sunda Chain as far as Wetter. Galvano mentions, amongst the islands which they passed near or sighted, Bali, Anjano, which Mr. Tiele identifies with Kangeang, Sumbawa, Kalao, Solor, Mauluca (perhaps Malua or Ombay), Wetter, and Rosolangium, which I am inclined to think may be a corruption of Nusa Kalkoun, just as we find Nusa Telo corrupted into Rosetelo, and Nusa Laut into Rosalao. Against this must be placed the authority of Barros, who identifies Rosolangium with Rosengain.

Other chroniclers of this voyage now conduct the ships to Amboyna, but Galvano states that the voyage was continued eastward to the Aru Islands. Not only does Galvano's carefulness and trustworthiness make it morally certain that his statement is correct, but also the fact that he mentions a local detail, which shows that he knew what group he was writing of:—"They came to other islands, the Arus, from which the dried birds come, which are so highly esteemed because of their feathers." The dried birds, "Os passaros myrrados," were no doubt the great Paradise Birds, *Paradisea apoda* of Linnæus, so named in 1760 from dried specimens. Maximilian Transylvanus wrote in 1523 that the people of Marmin—by which possibly Aru is meant—hold the bird in such reverence that they believe that by it their chiefs are safe in war. They reverenced the bird because the Mahometan Malays had told them that it was born in Paradise, and that Paradise was the abode of those who had died, and in consequence of this doctrine, and because Mahomet promised such wonderful things concerning this abode of souls, the Marmin

chiefs embraced Mahometanism. The legend about Paradise being the birthplace of these birds, and that other form of the same legend to the effect that they never rested upon the ground, nor upon anything that grew upon it, but that they sometimes fell dead from the sky, arose probably from the Aru methods of killing and preserving the birds ; for the islanders conceal themselves under mats of leaves placed in the trees which the birds frequent, and shoot them with blunt-capped arrows, so that they are killed without any wound and without blood being shed. Then the wings and feet are cut off, and the skin is preserved by smoking, and perhaps in Galvano's time by embalming, as he calls them "Passaros myrrados." As the skins were not seen in a complete state, with wings and feet—by the traders, it was supposed that the birds possessed neither, but that they floated through the air in a beatific way.

There are traditions extant in the Arus to the present day respecting the contact of the islanders with certain strangers who came to Wanumbai before the Bugis came to trade there. This must have been before the time at which Galvano wrote, for the dried birds of which he speaks were no doubt exported by the Bugis. These strangers "were wonderfully strong, and each one could kill a great many Aru men, and when they were wounded, however badly, they spit upon the place, and it immediately became well." And they made a great net of rattans, and entangled their prisoners in it and sunk them in the water ; and the next day, when they pulled the net up on shore, they made the drowned men come to life again and carried them away. (*Wallace's Malay Archipelago*, chap. xxxi.) It is very probable that these legends originated in a Portuguese visit to the Aru Islands ; indeed, it may have been this very visit of Abreu which gave rise to them. They are to us very childish and absurd, but it must be remembered that many of the legends believed by European writers in the seventeenth century are much more childish and absurd than these.

Galvano's statement about the Aru Islands is not so important, as the further statement that Abreu came "to other islands which lie in the same parallel of south latitude in 7 or 8 degrees, and they are so close to one another that they appear all one land."

Abreu then, it appears, continued his voyage eastward from the Arus. Most probably he directed his course to the south of these islands, leaving their shallow tripang banks to the north. In five or six days' sailing he would be off the coast of New Guinea. At first the land appeared to be continuous, but as he came nearer he discovered that there was more than one island. The only break in the coast-line at this part, namely between 7 and 8 degrees south, is the northern entrance of Dourga Strait, between New Guinea and Prince Frederick Hendrik

Island. Here, then, I suppose Abreu to have arrived. The southern outlet of the strait is in about 8° 20′ S., and because this is a higher latitude than that indicated by Galvano, as well as for another reason which I shall adduce later on, I am inclined to think that Abreu did not pass through the strait, but that he only proceeded to a point about 15 miles within the entrance, that is, to about 7° 36′ S. At this point he would have proceeded far enough to ascertain that he was in a strait or deep inlet, not in the estuary of a river. As to the value of his discovery from an Australian standpoint, that may be roughly indicated by recalling the fact that in Dourga Strait Abreu was within 320 miles of Cape York, or 50 miles nearer to Australia than Columbus was to America when he discovered San Salvador in his first voyage.

At New Guinea (a name which only appears at a subsequent period) Abreu had accomplished a course of more than 500 leagues, but from what point Galvano does not definitely state. The distance from Dourga Strait to their halting-place at Gresik would be about 500 leagues or 2,000 miles.

From the New Guinea coast Abreu directed his course towards Banda, and passed to the north of the volcanic island of Gounong Api—a name which, with the usual uncertainty of the Portuguese about native names, is corrupted by Galvano or his editor into "Guamape." Banda, however, is left behind for the present, and the ships continue their course to Bourn. This island should have been the point of departure for Ternate had Abreu been desirous of proceeding to the Moluccas proper, but instead of doing so he retraces his course in order to visit Amboyna, then "coasted along a coast there which is called that of Muar d' Amboyna," apparently Ceram, the western peninsula of which, Hoewamo, was sometimes called "Batochina de Muar." About 10 miles west of the narrow passage of Kebba Kebba, between Kelling and Ceram, there is a round bight with a high cliff on the east side of it, on which stood the village of Guliguli, whilst at the bottom of the cliff lay the associated hamlet of Keliwalanga. In this harbour Abreu anchored.

Valentijn tells us that the people of this part of Ceram were more like Macassar men than like the other Ceramese, but he is probably referring to settlers from Celebes, who came here at a later period than that of the visit of Abreu. This part of Ceram became a great trading centre for the Bugis, and they, as well as the people of Goram and Ceram Laut, made voyages to Onin, in the west of New Guinea, in search of massoi bark, wild nutmegs, and boxes of native manufacture ornamented with shell-work. In the seventeenth century the inhabitants of Guliguli made themselves obnoxious to the Dutch by their smuggling practices, and could not be persuaded to obtain permits to carry on their old

trade from the officials of the Company. As a chastisement the Dutch burnt Guliguli in 1621, but the Bugis replied by fortifying their cliff. In 1659 three of the Company's ships and a fleet of kora-koras was sent against them and dislodged them from Guliguli, but they speedily established another fortress at Solothay, 2 miles further east. This place was also taken and destroyed, and a Dutch fort erected on the site of Guliguli. When peace was at last made a few people returned to Guliguli, but their numbers were so greatly reduced by the attacks of the Dutch and the raids of Kilwaru slave-traders that in 1705 Willem de Rieu, who was conducting a hongi round Ceram, found only one house standing on the cliff and two houses in Keliwalanga. *Valentijn's Oud en niew Oost-Indien* II, ii, 2, and iv, 4. In this bay, then, Abreu landed and took possession of a village. Dead bodies were found suspended in the houses, "for," says Galvano, "here they eat human flesh." This was a hasty and unjust conclusion to draw, partly based, no doubt, on the dictum of Ptolemy that the inhabitants of the Javas were man-eaters, whilst Ptolemy in turn drew his information from Arab traders, always ready to magnify the barbarism of the non-Mohammetan races with whom they came in contact. I am inclined to think that the dead bodies which Abreu saw were awaiting burial. The account which is given by Mr. H. O. Forbes of the burial customs of the Timorese throws some light on this matter. When a death takes place amongst them not only must every blood relation of the deceased present a gift to the departed, but a death feast, and also a burial feast, must be celebrated. The death feast alone is sometimes on so extensive a scale that the family is reduced to poverty by it, and cannot afford to give the burial feast for a long time afterwards. Indeed this duty is sometimes postponed so long that it is only carried out by remote descendants. But as custom requires that the body shall not be interred until the feast can be given, it is folded up at the hips, inclosed in a mat, and suspended by a cord underneath a small pent-house formed in the branches of a tree, where it is left hanging until such time as the burial feast can take place. (H. O. Forbes : "*A Naturalist's Wanderings in the Eastern Archipelago*," p. 435.) From what I have gathered about Guliguli and its inhabitants, I am inclined to think that Abreu's visit took place before any migration of Malay settlers to that place, and that the people with whom he came in contact were indigenes of that division of the Papuans known as brown Papuans and sometimes as Alfuros. I have dwelt thus long on Guliguli and the vicissitudes of its history because it is an interesting village from many points of view—from a geographical, a historical, and an ethnographical—and because it is one of the few spots in the world which can be identified in connection with a great discovery voyage of the

sixteenth century. At Guliguli the ship commanded by Serrão—an Indian vessel taken at Goa—was burnt, "for she was old and rotten." Other accounts say that the vessel was wrecked and the crew taken on board the two other ships, which then proceeded to Banda, where at "Lutatão" the Portuguese were well received by the natives. The main Banda group consists of three islands—a larger and two smaller ones. One of the latter is merely a volcanic cone, named Gounong Api, a generic term signifying mountain of fire, borne by several islets of the archipelago. Gounong Api, together with Bandaneira and Lonthoir or Great Banda, form a secure land-locked harbour of great beauty, its shores clad with vegetation, except where the volcano raises its barren eminence above the bush-covered lower zone. "Lutatão" is probably a corruption of Ortattan, a village on the north coast of Great Banda and one of the principal trading centres of the group in the sixteenth century.

Banda is the home of the nutmeg, and here Abreu was able to obtain a full cargo of nutmeg and mace as well as of cloves. Here, too, he erected on the beach a stone pillar with the arms of Dom Manoel, as he had also done at Gresik and in Amboyna, in token that these places were henceforth under the supremacy of the Crown of Portugal. Having taken in his cargo, Abreu sailed for Malacca. Why he did not proceed to the Moluccas proper is uncertain. Castanheda attributes it to unfavourable weather. Others say that his cargo was fully made up at Banda. But he seems to have had some special reason distinct from these for curtailing his voyage, because he wished to make great haste to return to Portugal, in order personally to convey to the king the assurance that the way to Banda was an open one. But Maffei relates that he died on the homeward voyage, "deluded by a vain hope." As for Francisco Serrão, he was either separated from the other ships by accident or parted company designedly, and, after many exciting adventures, found his way to Ternate, from which place he maintained an important correspondence with his friend Magellan, and where he died in 1521.

When Abreu took possession of the island of Banda, he fixed its position by implication; for, by treaty with Spain, the Portuguese were only entitled to annex territory for the space of 180 degrees eastward from a line of demarcation fixed in 1494 by the capitulation of Tordesillas at 370 leagues west of the Cape Verde Islands, or in about 47° 30′ W. of Greenwich. After the discovery of the Amazon by Vicente Pinçon in 1499, the line was considered to fall through the western mouth of that river, or about $2\frac{1}{2}$ degrees too far to the west, for the fiftieth meridian of west longitude crosses the western mouth. If we measure 180 degrees eastward from that point, we arrive almost exactly at Bandaneira, which lies under 129° 50′ of east longitude.

Here we gain a glimpse of at least one reason why the Portuguese historians make no reference to Abreu's visit to the Arus and New Guinea. These places lay outside of the Portuguese Hemisphere, and it would not have been expedient to enlighten the Spaniards regarding newly-discovered land within their boundary. For the Spaniards did not accept a delimitation which placed the Moluccas outside of their hemisphere. It must be remembered, in justification of the Spanish claim, now known to have been erroneous, that the existence of the wide Pacific, and all its enchanting islands, was not even surmised at the period of which we speak. It was not till Magellan had actually crossed it that the Spaniards had any idea of the distance from the new world discovered by Columbus to the old world of Ptolemy and the ancients ; and even after that voyage, and in consequence of miscalculations of longitude made in the course of it, the width of the Pacific was greatly under estimated.

To find a short and direct passage to the much-coveted Islands of Spices was the great ambition both of Spaniards and Portuguese before the eventual discovery of Magellan. Columbus held that a strait existed through the Panama Isthmus, misunderstanding, perhaps, the accounts which he received from the Indians of a sea beyond the isthmus. One of the objects of his last voyage of 1502 was the discovery of such a strait. Further south, to the coasts of Brazil and Patagonia, the Portuguese, from 1501 onwards, were continually sending out expeditions in search of such a passage, and several breaks in the coast-line, such as the mouth of the Rio de la Plata and the Gulf of St. Mathias, had been taken for the entrances of straits.

The idea of finding a strait by sailing eastward from the so-called South Sea into the Atlantic occurred to the Spaniards immediately after they had established themselves in Darien. And it is not unlikely that the idea of making the discovery by sailing round the Cape of Good Hope and on eastwards until they reached the Columbian land-barrier may have occurred to the Portuguese.

Albuquerque, we know, held that the distance from Malacca to Brazil was only a short one. This appears from one of his letters to Dom Manoel. *(Cartas de Albuquerque.* I, 64–65.) And there would be nothing unreasonable in conjecturing that Albuquerque had ordered Abreu to sail on till he reached the new world with the object of reconnoitring it in the hope of finding a passage through it, should the time at his disposal permit. That Abreu thought he had made a discovery of some importance is evident from his desire to return at once to Dom Manoel with the news that the way to Banda was open. But the eastern route to Banda had been known to be open ever since the discovery of the Cape route. It was the western route that it was feared was closed by intervening land of great extent and to say that the

way to Banda was open before the Pacific Ocean had been even seen could only mean that Banda was attainable by sailing westwards from Europe as well as by sailing eastwards.

In concluding the examination of this voyage, let us inquire what trace it has left on the cartography of the period. I only propose to deal now with the New Guinea portion of the voyage. I would remark by way of preface that experience has shown me that it is only safe to accept the evidence of maps when the indications of discoveries which they contain are supplemented by the journals of the discoverers, or by the well-tested evidence of historians belonging to the period in which the discovery was made.

The earliest reliable representation of this part of the New Guinea coast known to me is to be found on a map entitled "Asia Partium Orbis Maxima," in the atlas "Speculum Orbis" of Cornelis de Jode, Antwerp, 1593. The same outlines, now united to the eastern portion of New Guinea so as to form one large island or portion of a continent, are repeated on the chart, "Moluccæ Insulæ" by N. J. Visscher, 1617, reproduced in Mr. Coote's "Remarkable Maps," Part II. They represent New Guinea very rudely, but place that island in its true relation to neighbouring islands of the Eastern Archipelago.

Now the only recorded voyage to the extreme south-west coast which took place in the sixteenth century was that of Abreu; hence, until adverse information is forthcoming, I think we may venture to associate these maps with his voyage. The entrance of a deep inlet is placed to the south-east of the Arus, approximately in the position of the entrance to Dourga Strait. But if Dourga Strait is intended, the inlet is erroneously prolonged in a north-easterly direction. Perhaps this may be explained by supposing (as I have already done on other grounds) that Abreu only reached that portion of the strait—about 15 to 20 miles within the northern entrance—which trends in an E.N.E. direction, and that this direction was supposed to be the constant one.

Time will not permit of my tracing in detail the subsequent history of this geographical problem; I must content myself with giving you a few leading dates in connection with it:—

1511–12. Voyage of Abreu.—New Guinea discovered, and regarded as a portion of the Columbian land-barrier.

1519–22. Voyage of Magellan and Del Cano.—The Pacific Ocean crossed, and New Guinea proved not to be a portion of that barrier.

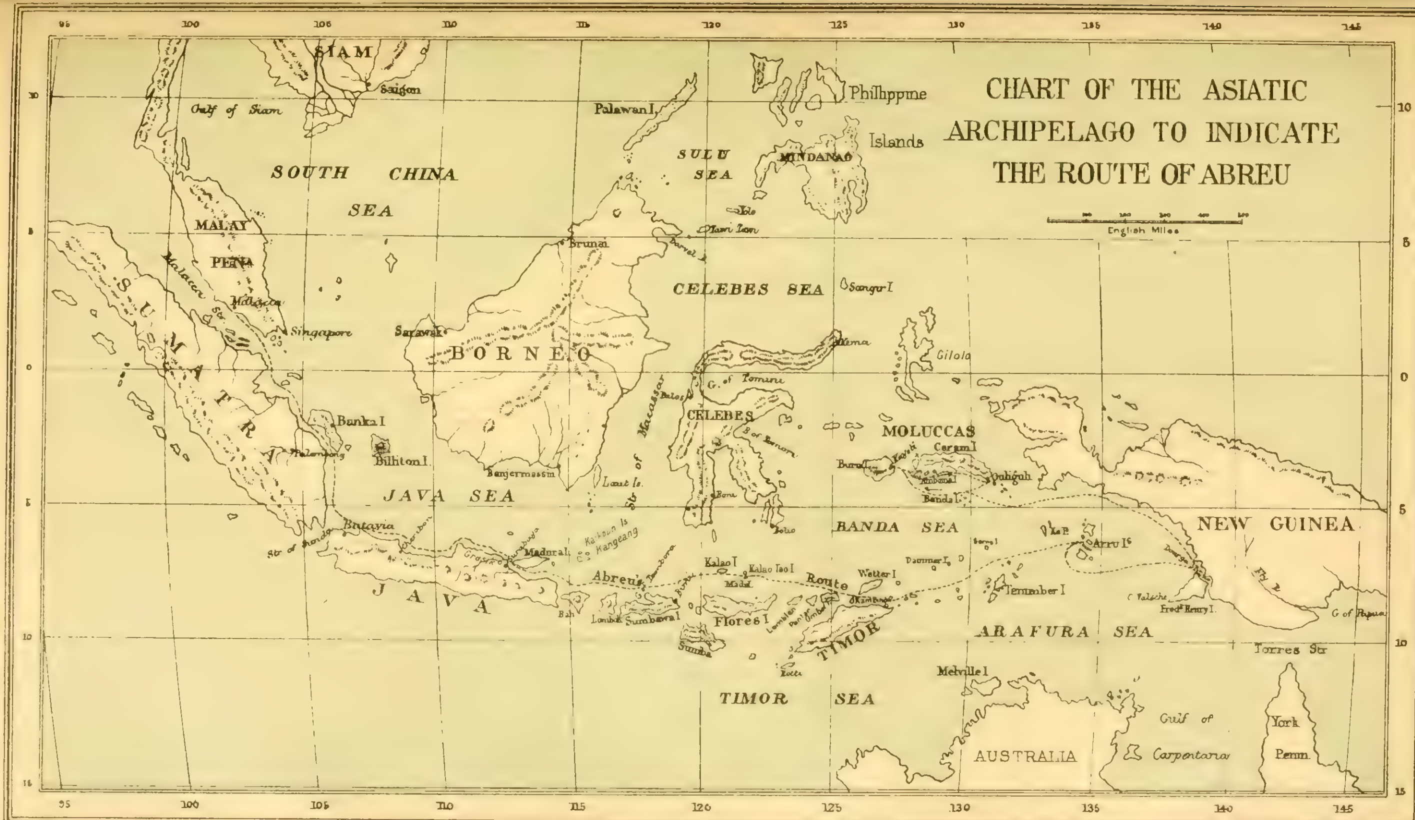
1606. Voyage of Willem Jansz.—Abreu's discovery of New Guinea corroborated, and the land supposed to be continuous with the south land known later as New Holland and Australia.

1762. Relation of De Torres showing that in 1606 he discovered the separation between New Guinea and Australia found at Manilla.

1825–26. Voyage of Kolff.—Re-discovery of the northern entrance of Dourga Strait, now so named.

1835. Voyage of Kool.—First passage through Dourga Strait, demonstrating the separation of Prince Frederick Hendrik Island from New Guinea.

I have tried to say something which would tend to remove the impression, prevalent in some quarters, that historical geography is a mere antiquarian fad; I uphold the position that it is eminently practical. Perhaps I could not better illustrate that position than in this manner:—Let us suppose that Dourga Strait had never been re-discovered to this day. The supposition is not an unreasonable one, since it was only discovered in its entire length sixty-three years ago. Now I hold that we have good grounds for believing that any intelligent and properly qualified captain of a ship or steamer having in his hand the account of Abreu's voyage as written by Galvano, and being furnished with the explanation of a few obscure points in the narrative, could sail from Sydney or any other port to the "islands lying in the same parallel" as the Arus, and there discover Dourga Strait. A result of that kind, the possibility of which seems almost self-evident, would surely be sufficiently practical to demonstrate the utility of this study to the most utilitarian mind.



The Discovery of New Guinea.

By J. R. MacCLYMONT, M.A.

Section F.

ETHNOLOGY AND ANTHROPOLOGY.

PRESIDENTIAL ADDRESS.

By A. W. Howitt, F.G.S., and Corresponding Member of the Anthropological Institute of Great Britain and Anthropological Society of Washington, U.S.A.

(*Delivered Saturday, January* 8, 1898.)

ON THE ORIGIN OF THE ABORIGINES OF TASMANIA AND AUSTRALIA.

The subject of my address has received the attention of many writers, who have attempted its solution, not by direct evidence, which, from the nature of the case, is not existant, but by inferences drawn from language, from custom, from the physical characters of the savages of Tasmania and Australia, and also, I regret to say, apparently out of the imagination of some writers as to what they assume must have been the facts.

Before entering upon the conclusions to which I have been led in this inquiry, it will be well to note in chronological order the views of various authorities :—

Mr. R. H. Davis* considered the Tasmanians to be scions of the Australians, and that their ancestors, being driven to sea in a canoe from the vicinity of King George's Sound, would, by the prevailing winds and currents, be apt to reach the western part of Van Diemen's Land. He selected that point of departure apparently for the reason that the word for "water" among the western tribes of Tasmania is similar to that used by the natives of Cape Loeuen.

In 1839, Captain Robert Fitzroy,† in his narrative of the surveying voyages of the "Adventure" and the "Beagle," between the years 1826 and 1836, attributes the origin of the aborigines of Tasmania and Australia either to a party of negroes who might

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* XII. † XIX, vol. II, p. 654

have been driven by storms from the coast of Africa, and thus reached New Holland or Van Diemen's Land, or to negroes either escaping or being brought to the northern shores of Australia as slaves by "red men."

The conclusions of Dr. Pritchard* as to the derivation of the Tasmanians and the Australians are noteworthy. They mark the great advance made in Ethnology since the year 1847, but they also disclose the germs of those beliefs as to the primitive races of mankind who inhabited the Australian and Melanesian regions and the Indo Malayan archipelago, which are now fairly established and accepted by Ethnologists.

He goes back to primitive black tribes inhabiting "Oceania, Oceanic Negritia, or Oceanic Negroland," at a time when the "Malayo-Polynesian" race had not yet entered the Indian Archipelago.

He considered that this Negrito race was spread by way of New Guinea over the adjacent Archipelago of islands, and that one branch took a more southerly course by the chain of islands ending at Timor, and lastly entered Australia.

In the same year Dr. Latham† stated in the Appendix to the narrative of the surveying voyage of the "Fly," during the years 1842–1846, that the Tasmanian language has affinities with both the Australian and New Caledonian languages, but in a stronger degree with the latter than the former. This he considered will at once explain the points of physical contrast between the Tasmanian tribes and those of Australia, and will indicate that the stream of population for Van Diemen's Land ran round Australia rather than across it.

Mr. Edward John Eyre‡ expressed the belief in the journal of his expedition of discovery into Central Australia in the years 1840–1, that there are grounds for the opinion that Australia was first peopled on its north-western coast, between the parallel of 12° and 16° south latitude. Thence he surmises that three great divisions branched out from the parent tribe, and from their offsets the whole continent was overspread.

Mr. McGillivray,§ after quoting Eyre, Pritchard, and Latham, says in his acconnt of the voyage of the "Rattlesnake," published 1852, that a common origin is implied by the belief in the unity of the Australian race. That it was not derived from New Guinea can scarcely be doubted, since Cape York and the neighbouring shores of the mainland are occupied by genuine and unmixed Australians, while islands of Torres Strait and the adjacent coast of New Guinea are occupied by equally genuine Papuans. Intermediate in position between the two races, and occupying the point of junction at the Prince of Wales Island,

* XLIV, vol. V, p. 214. † XXXVI. ‡ XVII, p. 405. § XXXVIII, vol. II, p. 81.

is the Kowrarega tribe, according to McGillivray, an Australian tribe altered by contact with the Papuan tribes of the adjacent islands so as to resemble the latter in most of their physical, intellectual, and moral characteristics.

Mr. James Bonwick,* in his work on "The Daily Life and Origin of the Tasmanians," published in 1870, devotes a long chapter to their origin. So far as I am able to gather his views, they appear to be that at the time when a now sunken continent connected Tasmania with New Zealand on the east and with Victoria on the west, the Tasmanians migrated therefrom and ranged round the coasts of the continent as the highway between what are now distinct lands.

He considers that the Australians came from the same centre as the Tasmanians, namely, the "sunken continent," and therefore, in their emigrations, established themselves directly upon the south-western part of Australia, and possibly after the separation of Tasmania from it.

The Tasmanians were thus isolated for several or many thousand years from the world's progress, and Mr. Bonwick feels "wonder that the Tasmanians retained the speech and form of man and the strength of human thought, the power of human love."

Professor Giglioli,† in the conclusion to his work on the Tasmanians (1874), regards them as being Australians with the hair of Papuans, retaining, but in a primitive form, the habits and customs of the former, or, to speak more correctly, as being the descendants of an earlier black race with woolly hair who were settled in the continent of New Holland. The Tasmanians were the last remainder of that race, having been preserved through the isolation of their country.

He says, in conclusion, that the Tasmanians were members of the great Papuan family, and owed their inferiority to the complete state of isolation in which they had existed since a very remote epoch.

The Rev. William Ridley‡ appears to have held the view, although he states it (1875) with some hesitation, that the Australians passed from New Guinea, from island to island, to Cape York. Having found their way onwards to the south and west, the necessities and jealousies of the numerous families that followed them forebade their return.

Mr. H. Ling Roth,§ in his most excellent work on the Aborigines of Tasmania, discusses the views of M. Topinard, Professor Huxley, Professor Friedrich Müller, MM. de Quatrefages and Haura, Dr. Garson, Mr. Barnard Davis, and other authorities, as to the origin of the Tasmanians. He says that it is quite

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* IV, pp. 264, 265, 269. † XXII, p. 147. ‡ XLVI, p. 119. § XLVII, p. 224.

impossible to define exactly the race to which they were most closely allied, but that a comparison of their physical and mental characteristics with those of other races which appear to have close similarities, tends to the conclusion that the Tasmanians were more closely related to the Andaman Islanders than to any other race.

Mr. R. Brough Smyth,* in the introduction to his work on the Aborigines of Victoria, published in 1878, says that it is difficult to believe the Tasmanians were scions of the continental tribes, and that if Tasmania was peopled from Australia it was at a time when the latter supported a race that in feature, character, and language was Tasmanian.

As to the Australians, he says that they may have landed from Timor, but that it is doubtful whether if a canoe full of natives landed anywhere upon the coast of Australia they could find subsistence. Yet he speaks of one stream of migration coming from the north-east, which divided one branch of which following the coast northwards, ultimately reached Gippsland ; the other again dividing at the south-eastern shore of the Gulf of Carpentaria, one section took a course along the coast westward and southward to Western Australia, and the other followed the course of the rivers that flow southwards into Cooper's Creek and the Darling.

In the "Australian Race," published in 1886, Mr. E. M. Curr† formulated a theory which may be condensed as follows, leaving those who desire to do so to peruse the somewhat remarkable reasons which are advanced in its support.

All tribes of Australia are descendants from one source, probably, indeed, from a shipload or canoeful of persons who originally found their way to these shores. According to the agreement between custom and language, they were negroes from Africa. These ancestors of the Australian race landed on the north west coast many ages back, and their descendants spread themselves over the continent by travelling along the north, west, and east coasts, and also through the interior.

In 1889, the Rev. John Mathew,‡ who has had opportunities of becoming personally acquainted with many examples of the aborigines, published an elaborate paper on the "Australian Aborigines." He considers them in relation to their origin, mythology, and traditions ; their implements, customs, language, mental characteristics, food, institutions and superstitions. He considers that Australia was first occupied by a purely Papuan people, or possibly by a people produced by a fusion of Papuans and Melanesians sparsely and unevenly distributed over the continent. Taking for granted that the cradle of the human race was

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* XLIX, p. LXII et infra. † VII, pp. 158 to 190. ‡ XXXIX, vol. XXIII, part II, 1889.

in Asia, he derives them from the north by way of New Guinea, and he looks upon the now extinct Tasmanians as the lineal descendants of the original Australians.†

He then supposes Australia to be invaded by a more advanced, fairer, straight-haired race which arrived at a very early period of the world's history, perhaps on the north-west coast, and poured into central Australia with a generally south-easterly current. Partly driving before it, partly darkening itself by the tide of life upon which it pressed, the stream inundated the whole country, but not to an equal depth.*

Finally, it is supposed that another invasion, apparently of Malays, took place from the north, first with some degree of continuity and then intermittently, winding about here and there, touching the shores at various places, and bending back inwards.†

The author then says that upon the Papuan aborigines "the Dravidian influx" made a deep and general impression. The influx of the final arrivals, the Malays, was slighter and more partial.

Mr. R. Etheridge, junr., in 1890, in a most valuable contribution on this subject asked the question, "Has man a geological history in Australia?"† After reviewing the evidence derived from the discovery of stone axes, bone implements, oven mounds common in parts of Victoria, and the occurrence of a human molar in the Wellington Cave in New South Wales, he reaches the conclusion that the matter cannot be summed up better than by the Scotch verdict "not proven."

As to the Tasmanian aborigines, he remarks that the former geological connection of Australia and Tasmania appears to be a generally accepted fact, and that if such be the case, a vast period of time must have elapsed since that connection, allowing for the formation of Bass's Strait. He very justly observes that herein lies one of the strongest proofs of man's early existence in the island continent, although trustworthy geological evidence is still wanting as to the approximate date of his first advent in Australia.

Following Mr. Etheridge's paper, there appeared in 1892 a work on the Geology and Palæontology of Queensland, by Mr. R. L. Jack and R. Etheridge, junr.‡ In this, after quoting the paper just referred to, Mr. Jack discusses the question whether the dingo was introduced into Australia by the agency of man, and says that, although he is quite willing to admit that the dingo is an alien, it is yet open to question whether the agency of man was the only possible means of effecting his introduction to this island. He appears to think that the dingo may have arrived in Australia by some chance means of conveyance, or may have

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* xxxix, p. 382. † xv, pp. 259 to 266. ‡ xxxi, vol. i, p. 622.

simply walked overland. Mr. Etheridge adds to this in a foot-note, that there is not a fragment of evidence to show that the arrival of man was coeval with that of the dingo.

Dr. John Fraser has stated his views of the origin of the Australians in the introduction to his work "An Australian Language," published in 1892.* He holds that the negroid population of Australia originated in Babylonia, and that it was driven into southern India by the "confusion of tongues" which followed the attempt of Nimrod to establish dominion over his fellows. The overthrow of the Chaldæan monarchy, about 1500 B.C. by Arab tribes drove thousands of Kushites into southern India, where they took refuge in the mountains of the Dekkan, and where to the present day there are Dravidian and Kolarian black-skinned and savage races.

The Babylonian Kushites are then supposed to have been driven out of India into the Malay peninsula, Papua and Timor by Dravidian tribes who came down from Central Asia. Finally they found their way into Australia.

These conclusions appear to rest mainly if not altogether upon philological deductions which also cause the author to argue that the Australians, the Dravidians, Malays, Papuans, Fijians, Samoans, and the New Hebrideans were at one time part of a common stock.

A very important contribution to the literature of this subject was a memoir which appeared in 1896, the joint authors of which were Mr. R. Etheridge, jun., and Professor T. W. Edgeworth David, and Mr. J. W. Grimshaw.†

In carrying out the excavation for a canal at Shea's Creek an old land surface was disclosed with standing stumps of Eucalyptus botryoides; bones of dugong were also found confusedly heaped together, some of which were scarred transversely and obliquely with cuts having the appearance of cuts made by the direct blows of a sharped-edged stone tomahawk. Stone tomahawks were also found at a depth of six feet, the submerged forest being ten feet below low water.

The latest work with which I am acquainted which expresses an opinion as to the derivation of the Australian aborigine is the second edition issued in 1897 of Mr. G. W. Rusden's History of Australia.‡

The author places the original site of the Australian stock among the Deccan tribes of Hindustan, and says that in a prehistoric time some powerful class or race of invaders sought to impose the peace of death upon the ancestors of the Australians. Their safety was in flight, and they migrated southwards from island to island until in Australia they marched free from molestation.

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*XXI. † XVI, pp. 18 *et seq.* ‡ XLVIII, vol. I, pp. 84 *et seq.*

The Tasmanians, he thinks, once occupied the mainland, and were driven southwards by more warlike or skilful tribes. Although to float across Bass's Straits in a canoe might be sometimes hazardous, yet in calm weather it would be easy, and the so-called catamarans of Southern Tasmania could not be filled with water or upset.

Such then are the views which have been recorded by various writers on the Tasmanian and Australian aborigines.

I shall now proceed to deal with this subject as it presents itself to me when looked at from the standpoint of present knowledge.

The level of culture of the Tasmanians is best indicated, apart from their customs and beliefs, by the the primitive character of their weapons and implements. The former were a spear, which was merely a thin pole hardened and pointed in the fire, and a club which was also used as a missile weapon. Flints chipped on one side were used for cutting, scraping, and being held in the hand, without a handle, for chopping.*

The only means they had for navigating the waters was a rude raft, or a bundle of bark tied with grass or strips of kangaroo skin into a canoe-like shape, by which a river or a narrow strait of the sea, such as that between Maria Island or Brune Island and the mainland, could be crossed in calm weather.†

Thus, as pointed out by Dr. E. B. Tylor,‡ the Tasmanians were representatives of the stone age development in a stage lower than that of the Quaternary period of Europe, and the distinction may be claimed for them of being the lowest of modern nomad tribes.

The Australians stand on a somewhat higher level than the Tasmanians. They are better armed, with the formidable reed spear propelled by the throwing stick, the boomerang, and a variety of clubs which served either at close quarters or as missiles, and for defence they had the shield. Their canoes are far in advance of the raft or the bundle of bark of the Tasmanians, and are able if necessary to cross narrow sea straits under circumstances where those would have been destroyed.

Their stone implements are either ground to an edge or fashioned by chipping, as among tribes living where material for the ground and polished type of hatchet is not procurable. But even in such tribes these are obtained by barter from other tribes.

The Australians may therefore be classed as representing hunting tribes of the neolithic age.

Certain inferences may be drawn from a consideration of their social customs and social organisation, but these may be more appropriately made at a later time in this address.

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* XLVII, chap. IV. † XLVII, p. 161. ‡ LVII.

Some of the writers whose opinions I have quoted have either stated in so many words, or have left it to be inferred by their statements, that the Tasmanians reached this continent by canoe or ship.

But there is not a tittle of evidence in support of the belief that the Tasmanians ever were acquainted with the art of constructing a canoe able to cross such a sea strait as that between Tasmania and Australia, much less wider extents of ocean. On the contrary the whole of their culture was on a par with the rudeness of the bark rafts.

I have long since come to the conclusion that one of the fundamental principles to be adopted in discussing the origin of those savages must be that they reached Tasmania at a time when there was a land communication between it and Australia.

It is only in the work of Professor Giglioli that I have found this clearly seen, where he says that there is no instance recorded of a people who have lost the art of navigation which they had once acquired.*

The Australians have also by most authors been credited with arriving in canoes or ships on the coasts of Australia.

But I am quite unable to understand how, since these authors picture them as settling down upon and then spreading along the coasts, they should have lost the art of constructing sea-going canoes, which would be as necessary to them as to the southern seacoast tribes of New Guinea or to the islanders of Torres Straits of the present time. There is no evidence of such a degeneration in culture, and before this belief can be accepted as a settled proposition some evidence in support of it must be forthcoming.

It might however be urged that the tribes living on the east coast of Cape York Peninsula and of the Australian coast of Torres Straits, as far as Port Darwin, are acquainted with and use outrigger canoes, and therefore may represent the condition of the first arrivals. On this the observations of the earlier navigators, and especially of those engaged in surveying voyages, are much to the point.

Mr. McGillivray, speaking of the year 1847,† says that the canoes seen in Rockingham Bay were constructed of a single sheet of bark brought together at the ends and secured by stitching. Near Shelburne Bay, on the east side of Cape York Peninsula, they were constructed of a tree trunk with a double outrigger, "and altogether a poor instance of those used by the islanders of Torres Straits." Further on, when at Cape York, he speaks of the ordinary outrigger canoe of the Straits, and of

* XXII, p. 146. † XXXVIII, pp. 81, 119, 125.

the friendly intercourse existing between the "natives of the southern portion of Torres Straits and those of the mainland about Cape York."*

These observations indicate the distance to which a knowledge of the outrigger canoe, derived from the islanders of the Straits, had passed southward at the time spoken of by Mr. McGillivray. To this may be added that, according to oral information, for which I am indebted to Mr. R. L. Jack, the use of the outrigger canoe extends now as far southward as Hinchinbrook Island.

As to the knowledge of the outrigger canoe by the Australians on the western part of the shores of Torres Straits, Mr. McGillivray also mentions that two years after the founding of the English settlement at Raffles Bay in 1827, the Bugis had taken advantage of the protection afforded to carry on trepang fishing, and that formerly bark canoes had been in general use, but that they were then completely superseded by others hollowed out of trees, which they procured ready made from the Malays in exchange for tortoiseshell, and in return for assistance in collecting trepang.*

Captain Stokes,† also speaking of the visits of Malays to Port Essington, says that the Aborigines obtained their canoes chiefly from the Malays, whom he elsewhere calls "Bugis." At the time at which he wrote, namely, the years 1837–43, canoes were used as far as Clarence Strait, but beyond that place he saw no single instance of any "proa or canoe."‡

It is therefore possible to fix the limits beyond which the knowledge of the outrigger canoe did not extend, namely, from Hinchinbrook Island, on the north-east coast of Queensland, to Clarence Strait in North-western Australia.

Some further light is afforded by a statement made by a man from Prince of Wales Island, whom I once met. It was that his tribesmen are accustomed to migrate periodically in their seagoing canoes, according to the prevalent winds, either southwards along the coast of Queensland, or northwards to the further islands of Torres Straits, or even to the mainland of New Guinea.

It seems to me that this practice must have existed for ages; indeed, since that time when the Papuan population settled on the Straits Islands and thus came to be neighbours of the tribes inhabiting the Australian mainland.

It is difficult to believe, if this coast at that time had been unoccupied by Australians, that the Papuans would not have settled on it as well as upon islands at no great distance northwards.

The Kauraregа of Prince of Wales Island are usually considered to be Australians with a strong Papuan mixture, which, judging from the example I saw, would be very marked. This mixture is

* xxxviii, vol. i, pp. 141, 146. † liii, vol. i, p. 388. ‡ liii, vol. i, p. 81.

easily to be understood when one considers the annual voyages by these people down the Cape York coast on the one side and across Torres Straits on the other, and that on these voyages they obtain wives from the Australian mainland and the New Guinea Islands.

I am therefore led to believe that the Australian ancestors must, equally with the Tasmanians, be held to have reached this continent by some land connection, or, at least, a land connection so nearly complete that the breaks in it might be crossed in vessels no better than the bark canoe of the present time.

If these conclusions are well founded there arise certain questions which demand answers. What evidence is there of a former land connection between Australia and other lands to the north or north-west, and between Australia and Tasmania within the limit of time fixed by the probable existence of man?

A reply to these questions can only be given by the sciences of physical geography and geology, and the time limit restricts the inquiry to those later Tertiary or Post-Tertiary lands from whence such migrations might have proceeded.

Thus their direction is indicated as having been probably from the north or north-west of Australia.

Dr. Wallace, in his classical work on the Malay Archipelago,* directed attention to several matters bearing upon this question, which still remain as significant as when he wrote them in 1869.

A deep but narrow sea channel, being part of what is now known as "Wallace's Line," separates areas of shallow seas bordered by great ocean depths,† while the boundaries of the shallow seas indicate the former extension on the one side of the Austral and on the other of the Asiatic continent.

The chain of islands which extends from the Malay Peninsula towards Australia, ending with Timor, when considered in connection with the boundaries of the shallow sea, represents a former continental extension, probably only broken by the channel between Bali and Lembok,‡ and a channel between Timor and Australia, 20 miles in width.§ The former, which is only 15 miles wide, has sufficed to stop the advance of the larger mammals from the Asiatic to the Austral region, and the latter strait has similarly prevented the Australian mammals from entering Timor.

If this was the line of migration of the early Tasmanians and Australians, we should have to assume either that they were able to cross the deep sea straits on rafts or in bark canoes, or that those sea straits were at such a comparatively recent geological time much narrower than the soundings suggest.

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* LVIII. † XXIII. ‡ LVIII. § LVIII, p. 323.

An alternative line of migration would be by way of Torres Straits.

The position of the Great Barrier Reef as to North-eastern Australia strongly suggests a submerged shore line of the continent; and if so, the numerous islands, islets, and reefs between Cape York Peninsula and New Guinea also suggest the former existence of a land connection now broken by subsidence.

Mr. Robert L. Jack points out that from Cape Palmerston to the Herbert River the coast is fringed by a strip of alluvial flat composed of alternating beds of clay, sand and gravel, the latter probably belonging to river beds. The old land surface, as proved by boring, is from 80 to 100 feet below the present sea level, and no river could possibly have excavated a channel to this depth while the land stood at its present level. This submergence, in all probability, took place after the period to which the extinct mammalia belonged.*

Mr. Jack has also pointed out to me orally that bays and estuaries into which rivers flow on the east coast indicate submerged valleys, and he has suggested that this comparatively recent submergence of the eastern part of Australia gave rise to Sydney Harbour on the one hand and Torres Straits on the other.†

An inspection of the Admiralty chart of Torres Straits between Cape York and the nearest part of New Guinea shows, not only a number of islands of some size, but innumerable islets and reefs studding a sea so shallow that it is only exceptionally that in the channels there is a depth of 10 fathoms. Therefore a movement of elevation of 60 feet would connect Australia and New Guinea by land. The 80 to 100 feet of subsidence which Mr. Jack assigns to the north-east coast in comparatively recent times would do more than merely connect the two lands.

So far as is yet known, the extinct mammalia to which Mr. Jack refers did not extend into New Guinea, and the absence of the platypus and the feeble development of the polyprotodont fauna in north-eastern Australia is considered by Professor Spencer to indicate that they spread northwards rather than southwards,‡ thus negativing the existence of an upraised Torres Strait at that time.

This suggests that, although there had been a land communication which admitted of a certain migration of Australian forms, it had ceased before the giant extinct marsupials spread into the extreme of Northern Queensland, and according to Mr. Jack that would probably have been in Post-Tertiary times.§ It seems therefore evident that there was a land communication between New Guinea and Australia at a comparatively recent period by which the Tasmanians, and subsequently the Australians, might

* XXXI, vol. I, pp. 613, 614. † XXXI. ‡ LII, p. 180. § XXXI.

have entered this continent. But this would have been anterior to the subsidence of Torres Strait as we now see them.

Thus all the evidence which I have been able to collect points to there having been a more practicable line of migration by way of New Guinea than by Timor.

At present too little is known of New Guinea to enable anything to be said as to traces of the Tasmanian and the Australian stocks in that island. But it is to be noted that New Guinea, Australia, and Tasmania were during our time, and as to the two former, still are occupied respectively by three well-defined types of man, effectually separated from each other by Torres Strait to the north and Bass's Strait to the south of Australia.

The relative positions of these peoples show that the Papuans, Australians, and Tasmanians must have occupied their respective locations in such manner that Bass's Strait stopped the march of the Australians, and Torres Strait of the Papuans.

It is now to be considered whether there are any data from which a fair inference may be drawn as to the former existence of a land bridge between Australia and Tasmania, across which the Tasmanians might pass to the latter country.

The time when such a land bridge between Australia and Tasmania may be thought to have existed is, so far as relates to the primitive Tasmanians, necessarily limited by the probable period of man's existence on the Australian continent, or in lands connected therewith in the past.

At present there is difference of opinion as to the precise geological age of the older Tertiary marine formations of Victoria, South Australia, and Tasmania.* But, for my purpose, I need merely refer to the period of depression during which the marine series of formations of older Tertiary age were laid down in Australia from the Snowy River, in Gippsland, to the Great Australian Bight, and on the north coast of Tasmania, as at Table Cape. It is clear that upon this followed an upward movement of the land, which was accompanied by, or culminated in, volcanic action in central and south-western Victoria, constituting the newer volcanic era, which by Victorian geologists has been placed in the Pleiocene epoch.† At that time a large extent of the central-western portion of Victoria was covered more or less by sheets or strips of basaltic lavas. Most of the ancient river-beds trending north and south from the Main Divide were more or less filled in by lava flows, which, while often confined between elevated Silurian ridges near the hilly country, spread out and united with the wide sheets that now constitute the plains.

To the northward of Ballarat portions of the Main Divide is of volcanic formation, and a wide sheet extending to the northwards

* XLV, p. 358. † XLII, p. 117.

finally disappears under the Post-Tertiary deposits of the Lodden Valley, and covers the ancient river-courses which trend towards the Murray River.*

Allowing for the previous depression during the Miocene and Eocene epochs, and an antecedent greater depression during the formation of the Victorian carbonaceous beds, there must still have been a continuous land surface of mountainous country far back into pre-Friassic, if not into Upper Palæozoic, time. During all that vast extent of geological time the rivers had been eroding their valleys in the higher parts of central-western Victoria, which in the upper volcanic era of the Pleiocene epoch were sealed up and levelled off by flows of basaltic lavas.

As seen in the Ballarat district, flows of basalt followed each other, separated by periods of time which permitted the accumulation of alluviums, until finally vast areas became basaltic plains, studded with volcanic cones.†

The older dividing range is in many parts covered, and the newer river-courses do not in places accord with the older drainage areas.

Thus were formed what are known to miners as the deep leads, trending from Ballarat northwards towards the river Murray, and southwards towards Bass's Strait.

It is not possible in the present state of information to fix with any degree of accuracy when in geological time these deep leads were formed, when volcanic activity was greatest, or when it finally terminated with the volcanoes of south-western Victoria, and the south-east of South Australia.

These latter are placed by Professor Tate‡ in that time when Diprotodon, Phascolomys Pliocenus, were still existing, and when the flora included Casuarina and Banksia.

The late discoveries of bones of Macropus Anak and other extinct kangaroos in the mine of the Great Buninyong Estate Company, to which I have more fully referred elsewhere,§ probably places the volcanoes of Mount Buninyong in the same time, and this can scarcely be placed further back than the later Pleiocene, if so far. This, however, I do merely as an approximation to the time when the Pleiocene rivers of central Victoria were sealed up by the basalts of the newer volcanic era, and thus formed certain of the deep leads of Victoria.

More recent marine formations of somewhat limited extent occur in Victoria, and elsewhere on either side of Bass's Strait, the position of which appears to indicate a comparatively slight downwards oscillation, followed by a still slighter upward movement, which, so far as I am able to form an opinion from the

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* XLII, p. 117. † XLII, p. 129. ‡ LV, p. lxix. § See pp. 741, 752, &c.

position of Post-Tertiary deposits in Victoria, Tasmania, and the islands of the Strait, may not exceed 50 to 60 feet.*

There are some grounds for the belief that the upward movement is still continuing.

In this brief summary the main features in geological history, and in the physical geography of Victoria and South Australia, which seem to have a bearing upon the questions discussed in this address, are the following :—

An elevation of the land following an Eocene or Miocene subsidence, which in the Pleiocene was accompanied by or culminated in the newer volcanic when the newer deep leads of Central Victoria were formed. Finally a resubmergence of the land in late Pleiocene or Post-Pleiocene times, by which Bass' Straits were formed.

I have been long impressed by the fact that the "deep leads" referred to—that is, the ancient river channels—are now at considerable depths below the surface over which the modern rivers flow, with but a slight fall to the sea by way of the Murray River valley.

During the past thirty years the Victorian Department of Mines has carried out an immense amount of boring with the diamond drill, by which the underground contours of the valleys, and also the trend of the deep leads, extending north and south from Ballarat, have been ascertained.

It seemed to me that a comparison of the data thus obtained, with the surface features, might prove of interest, and for this purpose I have selected the statistics of bores put down furthest north on three main leads, where the hilly country subsides into the great levels of the plains through which the river Murray winds its course towards South Australia and the sea.

Each locality chosen was also not far distant from the termination of the flow of basalt, by which the old valley had been levelled, and which itself was, at its termination, levelled of by the later alluviums of the plains.

The following are the data from which I was able to draw certain conclusion :—

No. 9 *Bore at Bung Bong.*

Height of surface above sea-level	714 feet.
Depth of deep lead channel below the surface† ...	300 ,,
Distance from the bore to Swan Hill, on the river Murray, by way of Bet Bet Creek and the Lodden River	200 miles.

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* XXXII, p. 320 *et inpa.*

† In each case, in order to approximate the conditions of the "lead" with those of the river Murray, I have deducted from the results of boring the depth of "wash," and have also allowed 5 feet for the possible depth of water.

No. 8 Bore at Charlotte Plains.

Height of surface above sea-level* ... ... 708 feet.
Depth of deep lead channel below the surface ... 270 feet.
Distance from the bore to Swan Hill by way of Tallaroop Creek and the Lodden River ... ... 180 miles.

No. 5 Bore of second line, near Baringhup.

Height of surface upove sea-level† ... ... 600 feet.
Depth of deep lead channel below the surface ... 226 ,,
Distance from the Swan Hill by way of the Lodden River ... ... 191 miles.

The distance from Swan Hill to the sea, following the channel up the Murray River, is about 950 miles.

The fall of the surface to Swan Hill is—from Bung Bong, 2 ft. 6 in.; from Charlotte Plains, 2 ft. 9 in.; and from Baringhup, 2 feet per mile. But the fall of the surface to the sea, by way of the channel of the river Murray, is only 2·75 inches per mile, and even that is not much, since, at Morgan, 400 miles up from the sea, there is only from 3 feet to 10 feet above sea-level, according to the season.‡

Thus, if these deep leads are imagined as being restored to their former condition of rivers, they could not flow out to sea by way of the river Murray unless the land were raised up, taking the mean of the three examples first given, by about 270 feet above its present height as compared with the sea level. This height of 270 feet, may, moreover, be taken as the minimum elevation required, since it would give no more than the present fall, which is improbable, when, as I shall point out, the character of the sea bottom in Bass's Strait is taken into consideration.

The fall southwards of the country from the main Dividing Range, near Ballarat, to the sea, is, also for a long distance over Newer Volcanic basaltic plains, analogous to those through which the abovementioned bores have been put down.

Here, also, the deep leads trending southwards have been proved by boring, and the same results have been obtained. But it must be borne in mind that there is a marked difference in distance to the sea in this direction. From Bung Bong, for instance, to the sea is 1,150 miles, while from Mount Mercer, where is one of the most southern bores, to Bass Straits is only 50 miles. Thus the face of the land in the latter case is much steeper when compared with the distance.

* On the authority of Mr. A. Everett, chief draftsman, Department of Mines and Water Supply, Victoria.

† I am indebted to Mr. Jas. Travis, Acting Secretary for Mines in Victoria, for this information.

‡ Mr. Stewart Murry, Chief Engineer of Water Supply, Victoria, has furnished me with these heights above the sea of the river Murray.

A bore put down to the west of Mount Mercer, proved the deep lead gutter at a depth of 113 feet from the surface, and one at Glenfine, near the Woady Yalloak River, bottomed at 161 ft. 4 in., of which 2 ft. 9 in. was heavy wash. All that can be said as to the leads on this side of the main divide is that they show the same general features as those on the northern side, but that any comparison with the outlets of these old rivers is not possible.

In order to test the conclusions drawn from the data obtained from considering the deep leads, I also examined the Admiralty Charts of Bass Strait and of the coast of Tasmania and the opposite Australian mainland.

On the accompanying map are shown the 50 and 100 fathom lines of soundings in Bass Strait, extending westward to include the mouth of the Murray River, and eastward as far as Jervis Bay in New South Wales.*

A line of soundings is also shown connecting Wilson's Promontory, in Victoria, with Cape Portland, in Tasmania, by way of the islands lying between these points. On this line the greatest depth is 32 fathoms, between Wilson's Promontory and Kent's Group. It is shallower between that island and Flinder's Island, and still shallower thence to Cape Portland.

A 35-fathom line on either side would indicate a plateau 80 or 90 miles wide about midway between the shores of the strait, and on the Victorian side widening out so as to extend up to Cape Howe.

There would be a low ridge from Wilson's Promontory to Cape Portland, with occasional elevations—now islands—rising at Mount Strezlecki to over 2,700 feet above the sea. These islands are, therefore, a submerged continuation of that part of the Cordillera which, in Victoria, ends at Wilson's Promontory, and as seen at Flinder's Island, they show the same features as Wilson's Promontory. The prevailing rocks, except a few isolated peaks of recent igneous origin, are granite and schists, which, on the low-lying tracts, are overlaid by deposits of Eocene age covered by recent formations.†

These islands are, therefore, composed of similar Palæozoic Plutonic rocks and metamorphic schists to those so largely represented in the Gippsland mountains, which terminate in a southerly direction in Wilson's Promontory.

An inspection of the soundings shows that the 50-fathom line encloses a comparatively level plateau which falls more rapidly,

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* From the Admiralty Chart.

† XXXII, p. 365.

While preparing this address my attention was directed by Mr. Everett, chief draftsman of the Department of Mines and Water Supply, to a paper read by Dr. Becker before the Philosophical Institute of Victoria, in which he points out the features referred to in this passage. II vol., p. 15.

and in places almost suddenly, to the 100-fathom line, especially on the western and southern side of Tasmania. Beyond this there are few soundings, but from those given the following statements may be noted.

The 50-fathom line is distant about 40 miles in a south-westerly direction from Cape Otway; at 10 miles further off is the 100-fathom line: at 20 miles further the depth is over 900 fathoms: finally, at 150 miles from Cape Otway, in the same direction, there is a sounding of over 2,300 fathoms.

Similarly, in a south-easterly direction from the Ninety-mile Beach in Gippsland, the 50-fathom and 100-fathom lines are distant 50 and 70 miles respectively.

South-easterly from Cape Pillar, in the extreme south of Tasmania, the soundings of 50, 100, and 1,000 fathoms are distant respectively about 5, 8, and 50 miles.

The lines of 50 and 100 fathoms soundings off the Murray mouth are distant therefrom about 100 miles, the two lines being apparently no more than 5 miles apart. At 100 miles further south there is a sounding of 2,840 fathoms.

The general conclusions derivable from a study of these charts are that the 50-fathom line represents a submerged plateau connecting Victoria approximately from Cape Howe to Cape Otway with Tasmania. From it there is a more rapid slope to the 100-fathom line, and thence a still greater slope into ocean depths. An elevation of 300 feet would therefore lay dry a tract of comparatively level country between Victoria and Tasmania, rising to a central ridge on the eastern side. The plateau would mainly lie not more than 100 to 200 feet above sea-level, but in places rising up to 3,000 feet. On the western side a deep bend to the north-east indicates the former channel of a river conveying the combined waters of all streams and rivers which now debouch between Cape Otway and Wilson's Promontory, whose deposits probably account for the unusual distance between the 50 and 100 fathom line, from the embouchure down to Cape Sorrell.

The plateau of low-lying land thus indicated flanking the eastern side of the chain of denuded and eroded mountains, where peaks are now islands in Bass Strait, would probably resemble the sandy and swampy country covered with dwarf scrub and coarse sedges which border Corner Inlet and separate Wilson's Promontory from the Gippsland coast ranges.

A great delta is indicated by these soundings, extending between Kangaroo Island and Cape Jaffa, a hundred miles beyond the present Murray mouth.

The former elevation of the land surface in the newer volcanic era may not unreasonably be held to be connected with the conditions shown by the soundings in Bass Strait. If so, the

50-fathom or even the 100-fathom line may be taken as marking the extension of the Australian continent southwards at the time in question.

That the elevation and subsidence of the land has been by widespread and not merely local movements is shown by the Eocene and Miocene marine series of Victoria, South Australia, and Tasmania, which, although subjected to elevation, are in the whole, at low angles, little beyond horizontal.

Mr. A. Montgomery, lately Government Geologist in Tasmania, to whom I communicated briefly the results of my researches as to the Victorian deep leads, most kindly favoured me with his views as to the evidence of movements of elevation and subsidence observable in Tasmania. I briefly summarise these from his written communications and from his published reports.*

In early Tertiary or even late pre-Tertiary times, equivalent to the age of the Flemington Plant Beds of Victoria, the northern part of Tasmania was relatively higher above sea-level by at least 270 feet than it is now.

A period of great basaltic extrusion covered and protected many of the Older Tertiary Sediments and culminated in a widespread subsidence to some 1,000 feet on the west coast and 700 feet on the north coast of Tasmania, where, for instance, the Beaconsfield lead is now below sea-level.* Subsequently there was a re-elevation of the land during Pleiocene and more recent times.

Two elevations of the land surface are here indicated, the older of which may be considered as being represented in Victoria by the position of old river valleys now filled in, but still indicated by flows of the "Older Volcanic." Such an example is that where, near Melbourne, the vestiges of a river system may be traced which drained approximately the same country as that now traversed by the Yarra and its tributaries, the Plenty, and Saltwater Rivers.† Another example is afforded by the stretches of Older Volcanic which extend from Neerim through Western Gippsland, and are apparently connected with the basalts of Phillip Island and perhaps Cape Schanck, thus indicating a river where embouchure is now below sea-level.‡

These observations on both sides of Bass Strait indicate a probable extension of the land southwards connecting Australia and Tasmania, but at a time far back from the Newer Volcanic Era, and beyond the limit of man's existence so far as it can be fixed in the present state of knowledge.

But it may perhaps be correlated with a "second connection between the Australian continent and Tasmania," which Professor Spencer§ considers to have existed "just at the close of the

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* XLI, p. 44. † XLII, p. 129. ‡ XLII. § LI, p. 180.

Cretaceous period and before the deposition of the Eocene beds of Table Cape and along the northern shores of Tasmania."

The re-elevation of the land to which Mr. Montgomery refers may be reasonably considered as that which I have connected with the Newer Volcanic Era in Victoria.

The commencement of this later connection of Tasmania and Victoria may be provisionally placed in the Peiocene epoch. What may have been its duration it is not possible to state within definite limits; but it may have been as late as the more recent volcanoes of south-western Victoria and the south-eastern district of South Australia.

Professor Tate says of the latter that they are newer than the Pleiocene sand and loess which are interstratified between the Mount Gambier limestones and the ashbeds of that place. He considers that man probably witnessed the showers of ash and the glow of internal fires from the cones of these volcanoes.*

The late discovery by Mr. S. Hart of the fossilised bones of extinct marsupials in black clay beneath the "second rock" and resting on volcanic ash in the mine of the Great Buninyong Estate Company, which I have more fully noted later in this address, shows that some at least of the volcanoes of the Ballarat district were active when *Macropus anak* was living.

If the cuts on one of the bones found there are finally accepted as having been on them at the time of their discovery, there will be evidence of man's existence as the contemporary of the extinct giant marsupials in the Newer Volcanic Era.

I may now advance a further step and consider what was the derivation of the primitive Tasmanians and Australians.

From the conclusions to which I have now been led, it follows that the Tasmanians were the autochthonous inhabitants of Australia, and that their preservation in Tasmania was due to isolation by the formation of Bass Strait.

The occupation of the continent by the Australians who, it may be reasonably held, were in a higher state of culture, and who were better armed than the Tasmanians, must have resulted in the amalgamation of the two races, either by the subjection of the latter, or, what is more likely from what we know of the Australians of the present day, by the extirpation of the former inhabitants, so far at least as regarded the males, and the absorption of the females into the tribe.

At any rate, whatever the process may have been, the result may be accepted of a strong negroid cross in the Australians.

Deducting this negroid element, there remains a residuum from which also must be deducted the "Malay element" of Mr. Mathew,† who finds in the Australian language traces of Malay

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* LV, p. lxix. † XXXIX.

influence. He says that they are not numerous, are not met with in the extreme north-west, where they might be expected, but turn up in unexpected parts of Australia, far removed from casual intercourse with Malays.*

In order to account for this Malay element, he introduces parties of Malays, who, either from choice or necessity, landed and became naturalised at various spots on the east, north, and west coasts of Australia. These Malays are thus supposed to have modified the speech of the people first immediately round them, and then landwards.†

As to this, it may be pointed out that Australia is three-fourths the size of Europe. What would be thought of an hypothesis based upon the landing of occasional parties of Asiatics upon the northern coasts of the Mediterranean, thereby introducing an Asiatic strain into the people inhabiting, for instance, Northern Germany!

The linguistic ground upon which this "Malayan" hypothesis rests consist first in identification of the interrogative pronouns, for instance, "minyanggai, or minna," of the Kabi language in Queensland, with the Malayan "mana," which, as Mr. Mathew himself points out, is properly the adverb "where," but which is used idiomatically to signify *who*, *whom*, *which*, and *what*; second, on twelve words selected from vocabularies of Australian tribes. Of these words, three, namely, the Malay terms for *moon*, *rain*, and *sun*, are, on reference to Dr. Codrington's work,‡ found to be also Melanesian. A fourth word, namely, the West Australian "yoora" or "ura," meaning "man," he identifies with "orang," but does not rely on it. As to the remaining eight words which are scattered over the continent, it may be that some might also be identified with Malayan and Melanesian words, and as in the case of isolated occurrences, it is always open to doubt whether the average collector of Australian vocabularies has correctly reported them. Even to the occurrence of the word "bapa" over wide areas in Australia meaning "father," much weight cannot be attached, since a similar or identical term may be found in languages the world over.

The Rev. Mr. Threlkeld, than whom no one has obtained so great a knowledge of an Australian language, denies that it has any close affinity with the Malay, either in word or construction.§ This opinion carries weight, not only by reason of his special qualifications, but because it relates to the languages of south-eastern New South Wales, where Mr. Mathew finds a strong Malay element.

A passage in Crawford's "Grammar of the Malay Language," published in 1852, speaks on this question with authority and

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* xxxix, p. 377. † xxxix, p. 378. ‡ ix, p. 78. § lvi, p. 82.

with no uncertain voice.* It is that he examined thirty languages from all the then discovered parts of Australia in quest of Malayan words without finding one, or the trace of one. They might have been expected in the language of Raffles Bay, not distant from the trepang fisheries of the natives of Celebes, but were absent from this as from all other of the languages. He remarks that, although the trepang fishers occasionally see natives of Australia, they hold no intercourse with them, and from what he knew of the opinions and prejudices of the former, he was satisfied that they would no more think of a social intercourse with them than with the kangaroo or wild dogs of the same country.

The trepang fishers here spoken of are the Bugis, a Malayan people, who form the principal nation of the Island of Celebes,† of whom M'Gillivray says that two years after the foundation of the English settlement at Raffles Bay they had taken advantage of the protection of Europeans to carry on the trepang fishery in the bay.‡

These remarks are confirmed by Captain Stokes,§ who says, in speaking of Raffles Bay, that six Malay prows came in, followed by others, soliciting permission to erect their establishments for curing trepang under the protection of the British flag, now for the first time secure from the attacks of the natives, whose hostility had until then forced every other man of them to keep under arms whilst the rest worked.

The visits of the Bugis to the north coast of Australia appear to have been far more numerous annually than might have been suspected. Mr. Earl, writing in 1837‖ of these very people, says that they visited the northern shore of New Holland annually with from 80 to 100 praws, and that their trepang and tortoise-shell fishing afforded employment for 1,000 men.

If this may be taken as having been a custom of long continuance, one might reasonably expect not only that there should be a strong Malay (Bugi?) cross in the tribes inhabiting the coast from Clarence Strait to Raffles Bay, but that there should be found a strong Malay element in the language of these aborigines. But from the quotations which I have given, the relations of the two peoples appear not to have been always friendly, and this may account for the absence of words of Malay origin in this very part of Australia where Mr. Mathew says we might expect to, but do not, find them.¶

It seems that all that can perhaps be properly said as to the influence of Malays (Bugis) upon the Australian languages is that on the north coast, limited probably to the range of the trepang, words might become naturalised in the languages of

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* x, Dissertation, clxxxii. † x, p. ccvi. ‡ xxxviii, Vol. I, p. 141. § liii, vol. i, p. 388. ‖ xiii, p. 390. ¶ xxxix, p. 377.

coast tribes, and be thence transported inland to such distances as the interchange of women as wives by those coast tribes might extend.

As I have pointed out, three of the twelve words identified by Mr. Mathew as Malayan are found, on reference to Dr. Codrington's work on the Melanesian languages, to be also Melanesian. Dr. Codrington shows conclusively that the elements which are common to them and the Malay have not been derived from the latter, but are common to all the ocean languages, from the Malagassy in the west to the Hawaiian in the east and the Maori in the south. He says, further, that this indicates an original oceanic stock language, from which the Polynesian, Melanesian, and Malay tongues have derived their common elements, which is now extinct, and of which the Malay is one of the younger descendants.* The presence of certain common words in the ocean languages testifies that the ancient speakers made canoes, built houses, cultivated gardens before the time when their posterity branched off in their way to Madagascar and Fiji.†

Such being the case, the primitive home of those speakers of the "ocean language" may be supposed to have been somewhere in the Indo-Malayan or Austro-Malayan regions, or, perhaps, to speak more correctly, in the ancient extensions of the Asiatic and Austral continents which they represent.

At any rate, the dispersal of the primitive speakers of the ocean stock-language must have been long after the migration of the Australians, and still longer after that of the Tasmanians.

It seems, however, not a little remarkable that the migrations of the offshoot, which is now represented by the Melanesians, should have extended from New Guinea, if not from a point further west, around, but at a distance from, and thus not touching Australia.

Compared with the sea distances, which must have been passed over (since the common stock-language proves that they were acquainted with canoes) before reaching Fiji, the stretches of sea between Timor and Australia, and New Guinea and Australia, must have been comparatively insignificant.

At any rate, it would seem that Torres Strait separated the Papuans from the Australians almost as effectually as Bass Strait separated the latter from the Tasmanians.

The Melanesians occupy a vast insular extent, touching New Guinea at the one end and Fiji at the other end, probably represent the older race on which the Papuans have intruded.

It seems not unreasonable to consider these facts as indicating migrations of three branches of mankind in successive stages of ethnical development and culture.

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* IX, p. 11, 26, 31, passim. † IX, p. 78.

If the Australians migrated from the north-west by way of New Guinea as I have suggested, it may be that they brought with them some elements of language common to the ancient oceanic stock-language, to crop out here and there in the Australian speech as words having a resemblance to Malay.

At any rate, as it appears to me, there must be very grave doubts as to the Malayan element in the Australian aborigines as formulated by Mr. Matthew.

Deducting, therefore, the hypothetical Malay ethnical element, which, if it exists at all, may be considered as merely local in Northern Australia, there is yet a limited Papuan or Melanesian element in Northern or North-eastern Australia, which cannot be altogether overlooked, and which in its negroid character cannot be altogether attributed to the original cross of the primitive Tasmanians.

I was much struck when comparing some men from Prince of Wales Island in Torres Strait, in near proximity to Cape York, with other men from the Cloncurry River, on the mainland, by the marked Papuan character of the former, and the marked Australian character of the latter. The intermixture, through friendly intercourse, between the Kauarega of Prince of Wales Island and the Gudang of Cape York is well known.

The Prince of Wales Islanders told me that they voyage periodically in outrigger canoes according to the direction of the wind, southwards along the Queensland coast, or northwards across the Straits to New Guinea.

This intercourse between Papuans and Australians by the intermediary islanders has probably existed for ages, and the admixture of race is indicated by the statement made by the latter to me that they obtained wives from Australia, and also from the islands to the north and from New Guinea.

Deducting these various elements, the apparent strong cross of the Tasmanian stock, and the certainly small admixture on the northern coast due to visits by the Bugis and the Papuan Islanders, there remains a large residuum to which the distinctiveness of the Australian type may be attributed.

To which of the great divisions of the human family may this Australian stock, on which the Tasmanian scion has been grafted, be assigned? Here is a difficult problem; but this much may with safety be asserted, it is not Ethiopic or Mongolian, and leaving out of question the American stocks, which can scarcely be seriously considered, there remains, therefore, only the so-called Caucasian as that great division to which the primitive type of the Australian may be referred.

In considering all the facts before me bearing upon the question of the origin of the Tasmanians and the Australians, I have been

much impressed by the immense periods of time which seem to be essential as one of the elements of any solution of the problem.

The level of culture of the Tasmanians has been termed by Dr. E. B. Tylor, "Eolithic,"* and that of the Australians probably stands in the Neolithic if not as regards some tribes on the border between that and the Palæolithic age.

The tribes of the Barcoo Delta were, when I knew them, still in their completely savage condition, and they used roughly chipped flints either held in the hand or fastened in handles with sinews and gum. This was, however, not from want of acquaintance with the Australian form of ground and polished hatchets, since they obtained such by barter from the hill tribes to the south, but because their country did not supply the material of which such hatchets were made.

The social organisation of the Tasmanians, so far as it can be made out from the unfortunately meagre accounts afforded by writers, appears to have been in some respects analogous to that of the Australians, but in so far of a character consonant with the lower level of culture of the Tasmanians.†

The organisation of the Australians, as seen in the socially most backward standing tribes—for instance, such as those of the Lake Eyre Basin—is that of a people but little advanced out of a regulated promiscuity, based upon the intermarriage of two totemic groups into which each tribe is divided.

The relationships and kinships of these people are also based upon, and naturally arise out of, the totemic intermarrying divisions, defining the relations of individuals to each other, in accordance with the principle of group marriage and descent, which are existing facts in those tribes; while in those which are socially more advanced group marriage is recognisable only in traces, or as mere survivals of custom.

Yet in these socially more advanced tribes, where there is individual marriage together with the recognition of descent through the father, the older system of reckoning relationships based upon group marriage still exists a living evidence of a departed fact.‡

The level of culture of the Australians cannot be held to be lower than that of the ancestral stock from which they separated. Their language discloses nothing that can point to a former knowledge of the arts higher than that of the present, in their naturally savage state; on the contrary, the terms of relationship show that the most advanced tribes were at one time in the status of those of Lake Eyre with group marriage and descent.

Therefore it seems clear that the Australians have advanced from group marriage to individual marriage, from descent counted

* LVII. † XLVII, p. 11, passim. ‡ XVII, XXV, XXVI, XXVII, XXVIII, XXIX, passim.

in the female line to descent counted in the male line; in fact, that they have progressed in so far along the same path of social development which the ancestors of the most advanced civilised races have pursued. This is not a little remarkable, and, indeed, suggestive, when we consider that the advance has been made evidently during a time, immense in years, during which the Australians have been apparently isolated in this continent from outward impulse, to work out as they have done their own society.

A long continued study of the organisation of Australian tribes has led Dr. Fison and myself to see that the division of the tribe into the two primary divisions, with definite social laws, points directly to that which we have termed the "undivided commune," and which is moreover clearly pictured by the Mura-Mura Legend of the Diëri,* and the entirely parallel Bungil Legend of the Woëworung Tribe of Victoria.

It seems, therefore, quite justifiable to hold that the social conditions of the parent stock of the Australians was that of the Lake Eyre tribes, if not, indeed, that of the Mura-Mura and Bungil Legends.

This would take us back far into primitive society, and the conclusion already provisionally arrived at, that the Australians must have reached this continent probably by a land connection complete, or almost complete, with the Indo-Asiatic or the extension north-westward of the Austral continent, will necessarily land us in distant prehistoric, if not in Pleistocene or older time.

It has been and still is frequently assumed that there is an ethnical relationship between the Australians and the Dravidian tribes of the Hindostan peninsula, and therefore this requires some special attention.

According to Professor Huxley,† any one who has ever seen an Australian and a Dravidian will be struck with the resemblance between the two. But this resemblance includes a negroid element of the Australian, which is not, according to other observers, always apparent in the Dravidians, who have, however, been subject to racial influences during long ages in India, from which the Australians have been protected by isolation.

The Dravidians are evidently not so uniform as appears to have been assumed, nor so marked a type as the Australians. Professor Keane‡ says that the separation of populations resident between the Himalaya and the Vindhya Mountains, from the Dravidian of the Deccan, is based wholly on the fact that the two former speak languages which are more or less directly descended from the Sanscrit. According to Mr. Baden-Powell,§ the Dravidians have been greatly affected by admixture of northern, possibly

* XVIII, p. 25. † XXX, p. 89. ‡ XXXIV, pp. 417, 418. § I, p. 88.

Aryan blood. At any rate, the admixture must be considerable on account of the tribal custom, as among the Nairs of the south-west coast, of taking temporary Brahman husbands for their female relatives.

From the time of Bishop Caldwell's "Grammar of the Dravidian Languages," in 1856,* to the publication of Dr. Fraser's work, "An Aboriginal Language," in 1892,* almost all writers on the Australians, who have treated of the language, have remarked more or less strongly upon the resemblance—in some instances, the apparent identity—between them and certain features of the Dravidian languages.

It is not within the scope of this address to do more than to note that some of the more striking features of the Australian languages. The fundamental character is that of agglutination, the numerals are restricted to two, three, rarely four, and more rarely five. There is an absence of an article, of numbers, and of gender, unless in rare cases, when, for instance, a postfix attached to a totem name indicates that a female bears it.†

The verb of the inflexional languages is represented by the aid of postfixes, and by the same means nouns may be declined in a variety of cases.

When compared with the Dravidian the Australian languages show a more primitive character, but there is a resemblance in structure, and, in some few points, even an apparent identity, as, for instance, in the first and second personal pronouns. But this is not much more than could be said as to analogous resemblances or identities with other languages of the same great "Ursprache," to which both the Australian and the Dravidian tongues belong.

Bishop Caldwell‡ directed attention to the personal pronouns, upon which so much stress is laid, and pointed out that the root "ni" is identical with the Dravidian and the Behistun-Scythian pronoun; so also is the "ni" of the Horpa dialect of the Thibetan nomads, with which the Australian "nunnia," "ngounie," and "nginte" may be compared.§

Dr. Bleek also writes much to the same effect.||

More recently Dr. Fried. Müller,¶ than whom no one can speak with higher authority in linguistic matters, says that no scientific objection can be taken to a statement that the Australian as well as the Dravidian languages belong to that family which Professor Max Müeller has termed Turanian, but that there is no foundation for saying more, and that even the statement that the Australian languages are all derived from one primitive tongue must be regarded with caution.

* VIII, p. 51. † XXI. ‡ XXV, XXVIII. § VIII, p. 316. || V, p. 89.
¶ XLI, p. 243.

To connect the Australians with the Dravidians in the manner commonly done seems to entirely overlook some essential elements of the problem. These appear to require that the original parent stock of the former must have existed far back in prehistoric or even in Pleistocene time, when the physical geography of the Asiatic and Austral continents and the racial character and distribution of the peoples inhabiting them must have very materially differed from those of the present time.

. Therefore, any ethnical or linguistic connection between the Australians and the Dravidians must be considered to be the relationship merely of two tribes co-descendant from a common and distant ancestral stock.

I should be most unwilling to appear to underrate the great services which the science of phylology is capable of rendering to anthropology; but it must be admitted that its professors are, unfortunately, not always possessed of that scientific caution which is so essential in all ethnological or anthropological inquiries. In Europe this has been shown by the results of the Aryan controversy; and it is sincerely to be hoped that no analogous results may be experienced here through attempts to solve the Australian problem by the aid of philology alone.

That science is merely one of the components of the comprehensive science of anthropology, and is, therefore, incapable of being a safe guide alone when attempting a solution of so complicated a problem as the origin of the aborigines of Tasmania and Australia.

The various provisional conclusions to which I have so far been led, will now admit of my advancing a step further in this inquiry and to attempt to indicate what appears to be the most probable source from which the Tasmanians and Australians have come.

Of all the attempted solutions of this problem, that which has been offered by Sir W. H. Flower and Mr. R. Lydekker* appears to me most nearly to fit in with the requirements of this case. They suggest that Australia was originally peopled by frizzly-haired Melanesians, such as the Tasmanians, but that there was a strong infusion of some other race, probably a low form of Caucasian Melanochroi. As to the identification of the Tasmanians with the Melanesians, the following may be applicable :—

Mr. H. Ling Roth has recorded certain conclusions, based upon the mass of data collected and discussed by him in his work on the Aborigines of Tasmania. Among others there is one which may be well accepted as agreeing with the weight of evidence, namely—that the Tasmanians were more closely related to the Andaman islanders than to any other race.†

* XX, p. 748. † XLVII, p. 351.

This would, however, place them among the Oceanic Negritos, who are now found scattered in small tribes from the Andaman Islands to the Phillipines and New Guinea,* and not among the later Melanesians.

It is noteworthy that all these scattered Oceanic Negritos appear to be mere survivals of a former widespread autochthonous race, which have been preserved either in inaccessible parts of Malaysia, like the Samangs of the Malay Peninsula and the now extinct Kalangs of Java, or isolated in islands which, like Tasmania and the Andamans, have been cut off by subsidence of parts of a former continent.

While it may be accepted that the present distribution of the Oceanic Negritos indicates a primitive population spread over Malaysia, or rather inhabiting the former southern extension of the Indo-Asiatic continent, it does not necessarily follow that they all represent the same branch of the primitive stock, but rather, more or less, nearly successive offshoots.

As to the Melanesians, Dr. Codrington's argument, which I have already quoted,† may be again referred to, in so far that the stock from which they have branched off must have been acquainted with (sea-going) canoes, houses, and the cultivation of gardens ; therefore, those ancient Melanesians could not have been the progenitors of the ancestors of the Tasmanians, being in a far higher level of culture.

It seems to me also permissible to distinguish the Tasmanians and Andamanese from tribes such as the Samangs and Kalangs. On these grounds I would suggest the following tentative hypothesis :—

An original Negrito population, as represented by the wild tribes of Malaysia ; a subsequent offshoot represented by the Andamanese and Tasmanians, and another offshoot in a higher state of culture originating the Melanesians.

As to the Australians, I may say that the discussion of the problem as to the origin of these savages and of the Tasmanians, has led me to conclusions which require, as the original stock of the former, such a race as would be supplied by the "low form of Caucasian Melanochroi," suggested by Sir W. H. Fowler and Mr. Lydekker. From such a stock the Dravidians may be also thought to have been in part derived.

Here and there in Asia are sporadic groups of people, characterised by black hair and dark eyes, with a skin of almost all shades, from white to black, frequently with profuse beards and body hair, and being in many cases in a condition of low savages.‡

Such are the Veddahs of Ceylon, the Hairy Ainus of Japan, the Maoutze of China, and perhaps the Todas of India. Such a

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* XXXIV, p. 254. † IX, p. 78. ‡ XXXIV, p. 418.

stock might have given the characters of the hair to the otherwise negroid primitive inhabitants of Australia, and also certain peculiarities of feature which are occasionally observed, and which are evidently and certainly not negroid in character.

I have before said, and desire again to repeat, that the conclusions to which I have been led as to the origin of the Tasmanians and Australians, necessarily demand a vast antiquity on the Australian continent for the former and even a very long period of at least prehistoric time for the latter.

There has been much hesitation in accepting any great antiquity for man in Australia. Mr. R. Brough Smyth* pointed out as far back as 1878, that in the hundreds of square miles of alluvial deposits which have been turned over by miners in Victoria very few aboriginal stone hatchets have been found, and there even at inconsiderable depths below the surface. Since that time, however, evidence has been forthcoming which may be held to probably assign man in Australia into Post-Tertiary, perhaps into Pleistocene times.

It may be well, therefore, to bring together those instances which have come under my notice in order that the evidence from these sources may be seen concisely in one view.

Mr. Bonwick† records the discovery of a "stone tool" by miners at Ballarat, 22 inches below the surface, in a place which had not been before disturbed. The author, however, according to his practice, gives no reference to his authority.

Dr. A. R. Wallace has communicated to me, for the purpose of investigation, the discovery in 1855, of an axehead of basalt at Maryborough, in Victoria, by Mr. A. C. Swinton, who was at the time engaged in mining.

Mr. Swinton says that he and Mr. M. C. Shore were sinking a shallow shaft on a small tributary leading into the main lead, when at a depth of about four feet from the surface and one foot from the bottom, Mr. Shore drove his pick into an axehead made of basalt. The shaft was sunk through cemented gravel with three false bottoms, and about half way down there was a hard band of cement.

By the courtesy of Mr. James Travis, the acting Secretary for Mines and Water Supply, Mr. Stanley Hunter, one of the officers of the Geological Survey, examined the place referred to by Mr. Swinton, and marked by him upon a parish plan of Maryborough.

Mr. Hunter reported to the effect that the tributary referred to by Mr. Swinton is one of the heads of the main Bet Bet lead, and as that lead is covered by Pleistocene basalt the lower strata in the contributary lead in question may be of the same age. Yet

* XLIX, vol. I, p. 364 † IV.

this is merely an assumption, as no fossil evidence of any kind is to be found.

In 1865, the late Mr. C. S. Wilkinson* together with Mr. Forde, found flint chips, a sharpened stone tomahawk, and several bone spikes or needles, together with bones of animals, in the sand dunes near Cape Otway. In the same locality they also found a similar bone spike with numerous seal-bones and shells of apparently existing species in beach material of pebbles and humus, resting upon carbonaceous sandstone and apparently intermediate between it and the overlying dunes.

In 1870, when visiting the Upper Dargo River in Gippsland, I was informed by some miners that in cutting a race for mining purposes they had turned up a stone tomahawk at about 2 feet below the surface. But as the race was cut out of the shingly alluvium at the side of the valley the find does not necessarily imply any great antiquity.

Mr. Bennett in his history of Australian Discovery,† makes a statement that in sinking wells and other excavations in the Hunter River Valley flat rocks were found with marks such as are made by the aborigines in sharpening their stone tomahawks. These were at a depth of 30 feet or more below the present surface and covered with a drift or alluvium.

In 1896, an important find of aboriginal stone hatchets was made at Shea's Creek, near Sydney, at a depth of 11 feet below water level, together with bones of dugong bearing such cuts and scratches, not recent, as would be made by direct blows of a sharp edged stone tomahawk. There were also several standing stumps of Eucalyptus botryoides, indicating a land surface, and the whole was covered by estuarine beds full of marine shells. The total alteration in the level of the land and sea was about 15 feet below high-water.

Mr. R. Etheridge, junr., Professor T. W. Edgworth David, and Mr. J. W. Grimshaw, the authors of the account of this discovery,‡ say that the date of the "aboriginal feast upon dugong," cannot be much below the limit of Post-Tertiary time, and it is even doubtful whether it is likely that the date can be carried back into Pleistocene times.

In 1897, an interesting discovery was made in the mine of the Great Buninyong Estate Company near Ballarat, of fossil marsupial bones beneath what is called by miners "the second rock."

At a meeting of the Royal Society of Victoria, held on the 2nd December, 1897, Mr. T. S. Hart, M.A., of the Ballarat School of Mines, exhibited these, being fragments of bones of two or three species, among which *Macropus Anak* was identified ; the bones

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* XIV. † III, p. 263. ‡ XVI, p 23.

were much mineralised, and on one, being part of a rib of a much larger species of kangaroo than *Macropus Anak*; there were cuts and marks, one on either side of one end, cutting off smoothly the broken edges of the bone, others on the flat side and one on the edge lengthways.

The cuts and marks had evidently been made with some sharp instrument, and the surface of the cuts appeared of the same character as the surface of the mineralised bone, but different in appearance to the surface of the edge where the bone had been broken, apparently by the point of a pick in extracting it.

However, as this bone was not found by Mr. Hart, but by some other person before his visit to the mine, the certainty that the cuts and marks upon it were not made after its discovery is still wanting.

The bones were found in a bed of black clay which contains in its lower part layers of volcanic ash. This interstratification of ash and clay rests partly on unstratified ash with many boulders, and partly upon the Silurian rock, and is 238 feet below the surface, being covered by two separate flows of lava. The black clay is part of an old swamp.

It is much to be regretted that the incised rib was not, as were other bones, found *in situ* by Mr. Hart, because if authenticated by the marks having been already made on it when discovered, it would be almost, if not quite, conclusive evidence of the presence of man in Australia in the Newer Volcanic Era as the contemporary of the now extinct kangaroos.

There may be added to this evidence the discovery of the crown of a human molar by the late Mr. Gerard Krefft in the Wellington Caves. As to this discovery, Mr. Etheridge, jun.,* says that the tooth appears to be completely fossilised, for on comparing it with the teeth of the larger marsupials from the Wellington Caves, the normal condition is without question similar. Yet its position in the cave, and association with the other organic remains entombed there, is open to doubt; and as no other human remains have been found at Wellington under similar circumstances, its precise age must remain uncertain.

If any reliance may be placed upon aboriginal tradition, the affirmative belief in the presence of man in Victoria during the Newer Volcanic Era is much strengthened.

It is said that there was a tradition to the effect that Mount Buninyong had at a distant time thrown out fire.

Mr. Dawson† also reports a tradition among the aborigines of the western district of Victoria that fire came out of a hill near Mortlake, and of "stones which their fathers told them had been thrown out of the hill by the action of fire."

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* xv. † xi, p. 101.

Although the "aboriginal feast upon dugong" at Shea's Creek may not be placed beyond the limit of Post-Tertiary time, and perhaps not even into Pleistocene time, the period of man's presence in Australia must have been very long.

The other evidence, if we could rely upon it, would, as to the tooth from the Wellington Caves and the incised bone from the Great Buninyong Estate Company's Mine, still further extend the human period, since man would then be seen to have been the contemporary of the extinct gigantic kangaroos at the time of the Newer Volcanic Era of Victoria.

Incidentally, as regards the period of man's occupancy of Australia, there is the question of his having been the contemporary of diprotodon and other giant extinct marsupials; and also another minor question: Mr. Robert L. Jack,* in repeating the question put by Mr. Etheridge, "Has man a geological history in Australia?" concludes with the further inquiry whether the dingo was introduced by him; and decides, although admitting that the dingo is an "alien," that the agency of man is not the only possible means of effecting his introduction to the island. He points out that the dingo may have simply walked overland; and to this Mr. Etheridge adds in a foot-note that there is not a fragment of evidence to show that the arrival of man was coeval with the dingo.

If my conclusions are correct as to there having been a land-bridge to Tasmania in the Newer Volcanic Era, by which we may suppose the Tasmanians to have crossed from the main land, the dingo could not have at that time been in what is now Victoria, or he would have "walked overland," even if he did not accompany the Tasmanians. The inference, therefore, is that he did not reach the southern coast until after the formation of Bass's Strait, although he may have entered Australia by way of an upraised Torres Strait.

A somewhat similar argument applies to diprotodon and his gigantic fellows. The formation in which diprotodon remains have been found in Victoria have usually been referred to as Pleiocene; but there must be great doubt, since, although occurring in tracts of country covered with newer volcanic basalt in the western district and near Gisborne, the deposits in which the remains have been found seem to have been superficial alluvium or dried-up swamps.†

Sir Frederick M'Coy has informed me in conversation that, in his opinion, the formations containing diprotodon remains in Victoria have usually been placed too far back into the Pleiocene. Mr. Robert Jack * says that in Queensland there is no evidence that the extinct mammalia went back to the Tertiary epoch. The

* xxxi, p. 608. † As, for instance, at Timboon, in Western Victoria.

tendency of evidence at present seems to be that diprotodon may have lived in Victoria in Pleistocene rather than older time; but it seems necessary that whenever it was, the connection of Victoria and Tasmania should at that time have been already broken. In other words, although the southern extension of Australia in the Older Volcanic and in the Newer Volcanic Era may have connected it with Tasmania, and thus served as means for the migrations of marsupials, either from Australia to Tasmania, according to the views of Mr Lydekker,* or from Tasmania to Australia, according to those more recently advanced by Professor Spencer,† the land connection in the Newer Volcanic Era was not available for diprotodon, although it probably was for the ancestors of the Tasmanians.

In dealing with the origin of the aborigines of Tasmania and Australia I have attempted the solution of a most difficult problem. I have looked at the questions arising out of it from more than one standpoint, and I have thereby been led to conclusions which contradict the views held and enunciated by fellow-workers whose opinions are deserving of respectful consideration.

All that I attempt to claim is that I have offered what seems to me to be a reasonably probable tentative hypothesis, based upon known facts.

My views will be accepted or rejected by competent authorities according as they stand the test of criticism, of time, and of the accumulation of further knowledge.

The conclusions to which this inquiry has led me may be doubtless modified by increased knowledge of new facts; but I venture to think, with some confidence, that the antiquity of occupation which I have postulated for the aborigines of both Australia and Tasmania in this continent will not be lessened.

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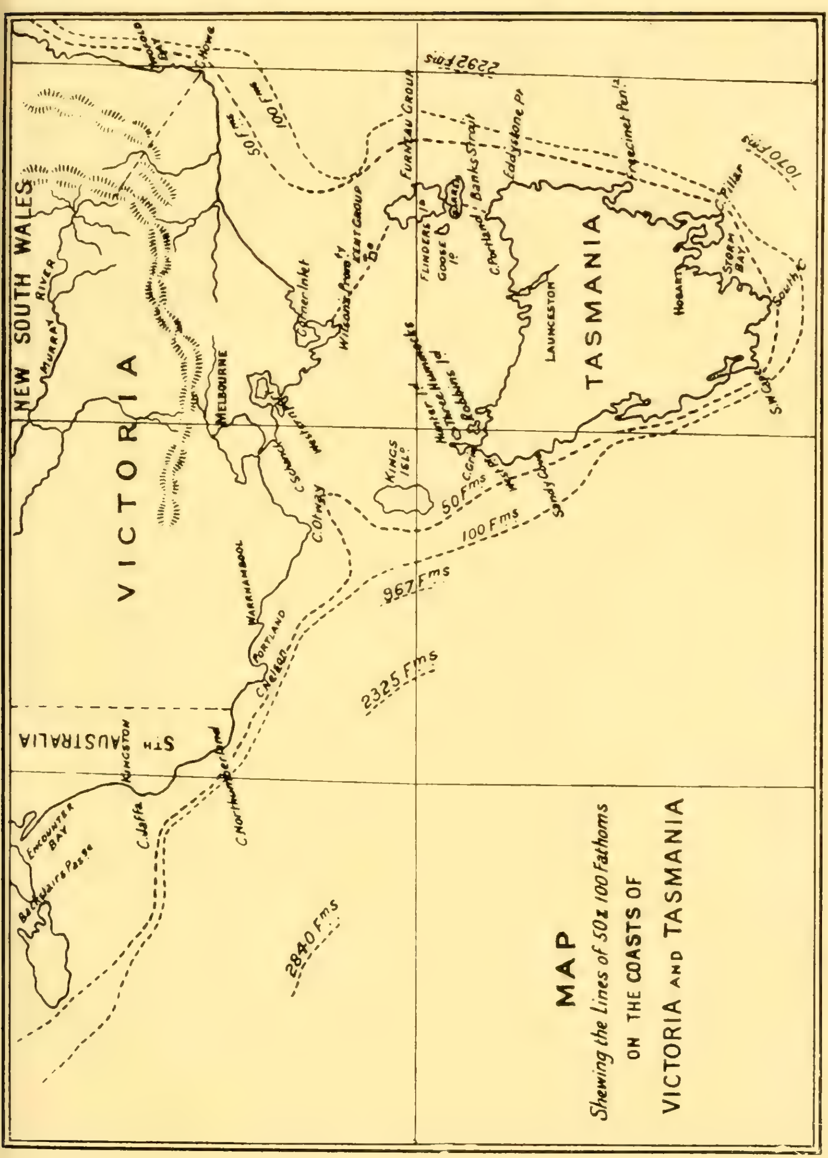
No. 1.—LE DIEU, LA NATURE, L'AME.

By Monsieur D. Marceron.

(*Read Friday, January* 7, 1898.)



The Origin of the Aborigines of Tasmania.

By A. W. HOWITT, F.G.S.

No. 2.—THE MYTHOLOGY OF THE EFATESE.

By Rev. Dr. Macdonald, Efate, New Hebrides.

(*Read Friday, January* 7, 1898.)

In a paper read before the Australasian Association for the Advancement of Science, at Hobart, 8th January, 1892, on "Efate, New Hebrides," I made a few concluding remarks on "Mythology," which I purpose now to expand. It will be of interest to Polynesian scholars to compare the Efatese mythology with that of other parts of Oceania, with a view to the solution of problems familiar to all such scholars. My object in this paper is simply to set forth what the mythology of the Efatese really is, and that without professing to deal exhaustively with the subject.

I. MAUI-TIKITIKI AND TAMAKAIA.

The Efatese say that these were the first men, the former being the grandfather (*tobuna*), the latter his grandchild (*sulina*). There seems to be a general notion that the story about them is best known among the Efatese of the islets to the north of Efate, called the Shipherd group, and a rock is shown to this day on one of these, Mai or Three Hills, to which the rope was attached by which they drew up the islands from the sea, and which bears the marks of the rope and of their feet. However, another version of the story has it that the rock to which that rope was attached is not on Mai, but on the top of a certain hill on the north side of Efate. Not only is the site of the rock various, but the story as told by different persons varies in particulars. Generally, however, it is to the effect that Maui-tikitiki and Tamakaia disputed as to which of them was the greater, and that Tamakaia proved his superiority. I shall, therefore, give the story, not as told to me by any individual, but as gathered from several separate accounts. It may be observed by way of preliminary that these names Maui-tikitiki and Tamakaia were obtained from the Efatese by the first missionaries who visited the island. Thus Mr. Gill, in his "Gems from the Coral Islands," says :—"It was found that these ignorant and degraded people needed not a Divine revelation to teach them the existence of a God. In common with all the Polynesian tribes yet visited they believe in the existence and dominion of a God, which they call Maui-tikitiki." And my friend, the late Mr. Murray, in his "Missions in Western

Polynesia," says, "They worship two gods whom they call Maui-tikitiki and Tamakaia, and to whom they trace the origin of all things." If Maui-tikitiki and Tamakaia are to be called "gods," they are no otherwise gods than other *Natemate* (literally, spirits of the dead), and it is quite erroneous to regard Maui-tikitiki as the chief god, or object of worship of the Efatese. I have only found one man who knew anything about Maui-tikitiki being worshipped ; he said that Maui-tikitiki's grave is on Mai, and that he had heard of fowls being sacrificed at his grave. The *Natemate* were the deities of the Efatese, and their religion a form of ancestor-worship. A general name "Supe" ('the ancients or the ancient, the ancestors or ancestor'), may be used either to denote ancestors or ancients, considered as men in this world (that is before they died), or as *natemate* dwelling in Hades (after they died). And hence such mythological persons as Maui-tikitiki are sometimes either individually or collectively spoken of under this name. As this word occurs in some of the following stories, what has just been said may suffice as to its meaning. We now come to the story itself :—

Efate (or Mai, as the case may be) was at the beginning the only land in existence, and Maui-tikitiki, his wife, and grandson, were the only human beings in existence. Maui-tikitiki used to give Tamakaia food, but concealed from him where he got it. He determined to watch carefully and find out for himself. At last he discovered that Maui-tikitiki had in a carefully enclosed place, shut in above as well as around, one banana plant and one yam plant. There were no other plants in existence, and, of course, no weeds. When the banana bunch was plucked off this plant, another bunch always replaced it, and so with the yam. A yam taken away was immediately replaced by another. Maui-tikitiki and Tamakaia *bilulu ki nafanua*—that is, strove for mastery in the world. Tamakaia said *Namanau ba wora*, "grass (or vegetation), spring up," and it did so. When Maui-tikitiki saw these plants growing where none had been before, he began to pluck them up, but as he went on clearing they immediately sprang up behind him again. Tamakaia charged him with being lazy, and said he did not want on this account to have any plants in the land except the one banana, and the one yam. Maui-tikitiki replied, "You will be the master of the world, if you can cover the face of the earth with vegetation (*nafurafura*)." Tamakaia did so. There was then a contest between them as to which of them should be the master of birds and fishes. Tamakaia called a bird, and in response to his call it came to his hand. Maui-tikitiki called it in vain. Tamakaia in like manner called to the fishes in the sea, and they came to his hand. Maui-tikitiki tried this also in vain. The next point of contest was as to the drawing up of the land out of the sea. Tamakaia made a

tremendous swing of a long rope fixed to the sky. He sat in this swing, and Maui-tikitiki swung him so that he went far out of sight; then from the swing he cast his hook, and, as the swing swept backwards, hauled up a land from the sea. Maui-tikitiki then took his place in the swing, and in like manner cast his hook, but in vain. Tamakaia hauled up all lands: when hauling up *Natonga* (distant or foreign lands, as Australia, England, &c.) his hook broke. It should have been noted that just as Maui-tikitiki had concealed his garden from Tamakaia, so the wife of Maui-tikitiki, in conjunction with her husband, had concealed the sea from him at first. It was shut in, in an enclosure, and he only discovered it by watching her when she went to bathe in it. He opened the door of the enclosure, and the sea, let loose, rushed out and spread all over the world as we now see it.

In another version of this story, of which the above contains the essential points, no mention is made of the swing. Tamakaia went out to sea, and, looking down, saw the various lands beneath the waters. Coming back to Maui-tikitiki he said, "Do you see anything by which you can show your superiority over me?" He replied, "No; and if you do, produce it, and you will be the greater."

"Cast your hook," said Tamakaia, "and get me a fish." He caught a turtle.

"Cook it," said Tamakaia, "that I may eat." He then drew up Tongoa from the sea, and founded it upon the bones of the turtle.

This process was repeated for every land. When Epi was drawn up it touched heaven. Tamakaia knocked it down, hence the great length of that island.

"Cast your hook," said Tamakaia, "and get me a fish." Maui-tikitiki did so, and got a whale.

"Cook it," said Tamakaia, "that I may eat." He then drew up Efate from the sea depths, and founded it upon the bones of the whale.

"Cast your hook," said Tamakaia, "and get me a fish." Maui-tikitiki did so, and got a porpoise and a dugong. Their bones were made by Tamakaia the foundation of Sydney (that is, of Australia).

At this point the grey-haired heathen (it is nearly twenty years ago) who was gravely narrating the story was interrupted by a travelled native standing by, who said, "No Sydney; England."

In drawing up Sydney and England (*Natonga*), however, so heavy was it with *bulumakau* (cattle), &c., that Tamakaia's rope broke, and, but for that accident, there would now be overland communication between Australia and the New Hebrides.

"Tamakaia then got the skin of a banana, and made a boat of it, determined to go and see England," continued the old man.

"He went to England, and never returned. He is known there as Jehovah. His banana-skin vessel became the white man's ships and boats. To this day there remain on two rocks on Mai two marks showing the truth of all this—the mark of Tamakaia's rope on the rock he used as a block, and the mark of his firmly-planted feet, where he stood when engaged in drawing all lands into visible existence. Maui-tikitiki died, and was buried on Mai."

The following is given in Efate as the song of Supe (Tamakaia) which he sang when pulling up the land from the sea:—

Maui-tikitiki ko maurimai
Ku matuatua,
Kinau mitau ki tonga,
Tonga mau:
Serinmatau, serinmatau,
Serinmatau è.

This song is sung by the people of Efate now in hauling up a heavy canoe, in dragging heavy logs, or anything heavy.

In Efate, Maui-tikitiki is said to have drawn up the lands from the sea, and little seems to be known about Tamakaia.

II. LEI MAUI-TIKITIKI.

In the above story the wife of Maui-tikitiki is mentioned. *Lei*, that is, female, Maui-tikitiki, is said by the Efatese to dwell in the sky (heaven); more particularly what we call "the man in the moon" is said to be *Lei Maui-tikitiki me atenina,* "Lei Maui-tikitiki and her grandchild."

On Efate she is regarded as having been present when the lands were drawn up from the sea. She saw the land in a fluctuating condition, just after it arose from the waters, and dashed the earthenware water pots, which she was carrying, violently upon it, with such a shock as to make it fixed and stable. But the pots were shivered into fragments, and hence the fragments of pottery found strewn all over Efate are called *nabura mai ki Lei Maui-tikitiki*, the shells of the water-pots of Lei Maui tikitiki.

The art of making earthenware pots, which is still preserved in Santo, had been lost by the Efatese before the advent of Europeans. But these fragments of pottery are sometimes called *nabura ki Supe*, the shells of the water-pots of *Supe*, where *Supe* may denote either Lei Maui-tikitiki or the ancients, or ancestors. Efatese axes used to be made out of shells and called *karau*. Now that European axes have come upon the scene, these, discarded, are found in the bush, near villages, and are called *karau ki Supe*, the axes of the ancients.

III. THE ADVENT OF LIGHT.

This story is told by a Mai man. There is a place on Mai called Lim. Formerly there was no light, and a man living here was annoyed at this, and at the consequent dampness and muddiness that prevailed. He took a club called *ta*, or *maltalia*, and smote at the sky, or floor of heaven. Five times he swung his club, and five times missed. The sixth time his blow was effective, splitting open the sky and letting in the Sun and Light.

IV. THE SEPARATION OF THE SKY FROM THE EARTH.

In the primeval times, the sky was close to the earth. A woman was raking the stones in her oven with a long pole. The top of the pole came against the sky, interrupting her work. Angry, she smote the sky with the pole, bidding it, with a loud voice, "Ascend!" The sky immediately began to ascend, and, notwithstanding that she entreated it to stop, it kept on ascending till it reached the position which it now occupies.

V. THE ADVENT OF NIGHT.

A chief of Meli had two children who were always crying, and as the sun was always shining in that primeval time, he could get no rest because they never went to sleep. He therefore set out on a journey in quest of Darkness and Night. He went round the island by way of Havannah Harbour, calling at the various villages. When he called at a village, the people—(this part of the narrative is sung)—asked him where he came from? He replied, "I come from the lower side of the island." "What have you come in search of?" "I have come in search of Night and Darkness." He went on and on till he came near to the most eastern point of the island, or south-eastern. Here the people directed him to a jutting promontory, called Baulelo, as to where he should obtain the object of his search. Provided with a bamboo vessel, he lay in wait on this promontory, and having seized Night-Darkness and enclosed it securely in his bamboo, started triumphantly on his return journey. Again he called at the various villages, and in return for the hospitality accorded him, and at the end of the meal, sang a song of complete satisfaction, took out from his bamboo a portion of the Night-Darkness and covered the land with it. Then the *supe*, or ancestral chief, wound up by falling into a sweet sleep.

VI. MAN, THE LORD OF CREATION.

In the beginning, it was still undecided whether man or some other should be superior in the world. They tied up man as if

he were a pig, and let the pig go as if it were a man. The pig went roaming about all day, and, caring only for itself, returned at night with its stomach well filled. It took no thought for the man, and cared not that he was hungry. *Man tangisi nerei* pitied man, seeing him in this evil case, and sundered the cords by which he was bound. He, seeing how inhumanly selfish and unfit to have authority over others the pig was, ordained that man should be man having the lordship, and that pig should be put in subjection, as we now see it.

VII. THE ADVENT OF DEATH.

At the first, it was not settled whether men should die (*mate*), or renewing their youth perpetually be immortal (*mulu*). Some said, "Let us die"; others said, "Let us be immortal (*mulu*)." *Man tangisi nerei* wished this latter to prevail; but *Pilake* burst in upon them while the deliberation was going on, and exclaimed, "You are deliberating about what? (the matter is practically settled). I have just buried my father and my mother. Beget offspring instead of them" (or to take their places). *Man tangisi nerei* wept, bewailing us (*tangisi-ngita*), so that his eyes are red to this day. Thus was established the existing order of things in which are set Death and Birth, the one over against the other, and in which as one generation goeth another cometh.

There are two little birds in Efate called respectively *Pilake* and *Man tangisi nerei*. The word *Pilake* signifies to be in mortal terror. *Pilake* is a dingy-looking bird, afraid of man, and keeping at a distance from him. *Man tangisi nerei* denotes, literally, "bird bewailing man"—that is, loving, pitying, and weeping over, or bewailing them involved in misery and death. *Man tangisi nerei* is a bird something like robin red-breast, venturing near the dwellings of men. It has beautiful bright red marks under its eyes; these are the marks said to have been caused by "weeping for men."

With respect to the word *mulu* in the above story it may be remarked that the Efatese explain its meaning in this connection in the following way:—The serpent, they say, casts its skin—that is, it *mulus*. By casting its skin it, so to speak, renews its youth. The old worn-out withered husk is slipped off and cast away, and the animal comes forth from it as if new-born, at once delivered from the effects of the wear and tear of time, and endowed afresh with youthful beauty, vigour, and life. If at the dawn of the world *Man tangisi nerei* had prevailed, and the decision of the fates had been that men should *mulu*, they should have never died.

The first man who buried the first dead in the beginning of the world is called *Maka Tafaki*. This, however, throws little light on the matter, as *tafaki* is from *afaki*, to bury.

VIII. HADES.

A chief of Bau was making an *intamate* (heathen feast), and searched for *Nabuma Nakabu* to be his *aure* (singer, or bard) at it. They told him that Nabuma Nakabu had gone to Tukituki, the west point of Efate, where is the entrance to Hades. He went to Tukituki and was told that Nabuma Nakabu had died, and been buried, and gone to Bokas. He went down to Bokas (the first stage of the under-world), and was told that Nabuma Nakabu had died, and been buried there, and gone to Magapopo (next lower stage of Hades). He went down to Magapopo, and was told that Nabuma Nakabu had died, and been buried there, and gone to Magaferafera. He went down to Magaferafera and was told that Nabuma Nakabu had died, and been buried there, and had gone to Maganaponapo. He went down to Maganaponapo and was told that Nabuma Nakabu had died, and been buried there, and had gone to Matika (the lowest stage of the under-world). He went down to Matika and inquired for Nabuma Nakabu, and they said to him, "Behold, there are his bones at the foot of a *nalas*" (a dark-leaved plant). He went and gathered his bones into a basket, and, reascending into the world carried them to Bau to the *Malel* (the *napea*, or dancing and singing ground of the *intamate*). The drums were beaten, and as the (to Efatese ears) inspiriting, measured sounds thundered forth, the bones of Nabuma Nakabu, heaped together in the basket, burst forth into singing!

Acccording to the Efatese every man dies six times, each time passing down to a lower stage, till he reaches Matika, and finally disappears.

IX. KARISIBUM AND MAKA TAFAKI.

The people of the sky perceiving that the tide was out and the reef bare, as it is at low water, came down and took off their wings (literally "thin sails"—*inlailaita*), which were white, and proceeded to fish with torches along the shore. *Sosoan* (a bird whose song begins at dawn) began to sing (like one at "cock-crow"), when they immediately came together, and, having laid down the fish they had taken, put on their wings. Then all joined in singing, and the wind rising blew them for a time backwards and forwards, till ascending they went on up into the sky.

This they often repeated. One night they came down and laid aside their wings, as usual, in order that they might fish along the shore. A man of the country, who had been watching them, saw where they had laid their wings, and when they were out of sight took the wings of one and hid them in a banana stem. In the morning, at the earliest dawn, they came together, laid down

the fish they had taken, and began to put on their wings preparatory to their return ascent. All did this but one whose wings could not be found after the most anxious search, and who was therefore left behind. She proved to be a woman, and the man who had stolen and hidden her wings came and took her for his wife. They lived peaceably together and had two sons. The man said to his wife "Let us give them names." The woman said "No, let them call each other what they please." One day the two youths were playing with bows and arrows, the one inside, the other outside the house, when the one called to the other "Maka Tafaki," who responded to his brother, addressing him as "Karisi Bum." Thus they received their names.

By-and bye trouble arose in the hitherto peaceful household. The man illtreated his wife, and said to her, "You are a wicked woman, cause of trouble and sorrow; go back to your own country." This made her heart sore, and she sighed for the lost wings, that she might fly away from all this turmoil and be at rest. One day she and her two sons were out. By accident the youths discovered a white thing in a banana stem. It was the thing their father had hidden there. Their mother was overjoyed. Determined to go, she first gave to her sons some information about her kindred, expecting that they would eventually see them. Then, putting on her wings, she sang the appropriate song, swinging backwards and forwards a few times while doing so, and went swiftly into heaven. They went home and told their father.

The two brothers grew up and became exceedingly clever and successful men. They excelled in everything, and became richer than any of the people of the land. They were therefore envied. They were told that they did not belong to that country at all, and bidden go in search of their mother's country. Their riches were the principal cause of this ill-will.. The aborigines, no doubt, expected to possess these by driving them away. These brothers, however, were not to be trifled with. They did things that made them both renowned and feared. For example, on one occasion they "beat the winds" with a club. For this purpose they climbed a high *nieru* tree (casuarina), and lay in wait for the winds. First came *Suepate* ('*sua*,' to come down from), the trade wind, at which they aimed a terrible blow but missed. Then came *Tokelan*, the east wind, which they also missed. So with some others. Finally came *Mastan*, the south-west wind. This was their last chance, and they determined to make the most of it. On came the towering wind in all its pride; down came the club on its forehead with thundering crash, and it fell with a shriek, lifeless and prone. And this is the reason that, while all the other winds blow rude and strong, the south-west wind blows gently, or at any rate, soon dies away.

The brothers, continually taunted with being adventurers, longed to get way to their mother's country. One day they were shooting birds with arrows. An arrow went up into heaven and stuck fast in the roots of a *namanga* (banyan) tree. Another arrow sent after it stuck in the end of its shaft, and so on and so on, until the chain of arrows reached from heaven down to the brothers' foreheads. They took hold of the nearest and pulled. It was firm. They climbed up to heaven. On getting up and climbing in over the roots of the banyan tree, they saw an old blind woman cooking six yams. They immediately thought, "Perhaps this is our grandmother of whom our mother used to tell us." Being blind she counted the six yams by feeling them with her hands. They went forward without making any noise, and took one away. She again went over the yams, counting them, and could make out only five. "Perhaps," thought she, "my grandsons, of whom my daughter told me, have come and taken the sixth." Remembering their names as they had been told to her, she called out, "MakaTafaki! Karisi Bum!" They immediately replied, "It's we." Thus ended their troubles.

According to another version of this Efatese story, the mother of Maka Tafaki, and Karisi Bum, was called Taurere. Before leaving her home in the world on account of the ill-treatment to which she was subjected by her husband, she comforted her two sons, and told them not to cry but to watch for a long rope that should be let down from heaven till it reached the foot of a banyan tree. They kept on watching, till one day the rope appeared as their mother had said. One of them first climbed up far out of sight into heaven, and shook the rope as a signal to his brother below of his safe arrival. The other then climbed up also. They saw their old blind grandmother and addressed her as *Lata*! She, on her part, had been forewarned by her daughter of their coming, and being requested to entertain them kindly, giving them sugar-cane, flesh, and yams to eat. After eating they said to her, "The skin of this sugar-cane is sharp for cutting. We will cut open your eyes with it that you may see." This they did. She said, "Oh children, you have made me all right; I am well." When finally they resolved to go down again to the earth they made a big *kawa* (woven basket), and put into it all things we now see in the earth, as fowls, pigs, male and female, and all the different kinds of food, one by one. They let down this loaded *kawa* from heaven by means of a long rope. At the end of this rope it kept swinging in the air over every land (or all lands), but the mountains at none of them were high enough (so that it might touch them). They hauled it up, and finally lowered it down at Utanilangi, in a valley called Papalaba, between two high mountains, so that the mountains should overhang the *kawa* and prevent it from swinging off into space. At

Papalaba the brothers took all the things out of the *kawa*. On this account (that is, because Maka Tafaki landed here), *Nakainanga bisi Maka*, the tribe that begets children entitled to the prefix name *Maka* (or *Mako)*, dwell at Utanilangi.

X. LAUTUMETA.

Lautaumeta was making an *intamate* in heaven. There were no animals (as pigs) for sacrifices, but only food (yams). All the different kinds of yams were at that time in heaven. There was only one kind in the earth then called *nakabu*. (But there are now twenty-seven different kinds of yams.) Lautaumeta was looking out for an *aure* to sing at his *intamate*, and heard that there was one on the earth called Nabuma Nakabu. This latter was asked to act as *aure*, and having consented went up to heaven to the *malel* of Lautaumeta. (It should be understood that Lautaumeta, and Nabuma Nakabu are both yams.) Maka Tafaki, and Karisi Bum said, "Let us beat for them the *napeas*" (drums.) They did so, and Nabuma Nakabu sang. Then all the different *nakainaga nani* (tribes, or kinds of yams) came and danced in the *malel*, till they stumbled and fell broken to pieces. Maka Tafaki and Karisi Bum gathered all the broken yams into a basket, and, when the song was ended, carried them down to the earth.

No. 3.—NOTES ON SOME CUSTOMS AND SUPERSTITIONS OF THE MAORI

By Elsdon Best, Tuhoe Land, Wellington, N.Z.

(*Read Friday, January* 7, 1898.)

The customs, traditions and superstitions of a barbarous race ever contain an element of great interest to those engaged in studies pertaining to the evolution of human culture in various forms, as also to the ethnologist, who seeks to determine the origin of races, their original habitat and migrations. Of the various neolithic races which have been overtaken by the advancing wave of western civilisation within the last century, none present more varied features of interest than that far-reaching people known collectively as the Polynesian race, and which people are found scattered over so vast an area of the island system. The Maori of New Zealand comprise one of the most vigorous divisions of that race, and in few groups throughout the Pacific can more

interesting matter be obtained anent the customs and strange observances of that ancient people who, for unknown centuries, have wandered "on from island unto island at the gateways of the day."

From the unknown Hawaikian fatherland, the ancestors of the Maori came in the dim past to seek their fortune on the many-isled sea. With dauntless courage they sailed forth in rude vessels to explore the ocean world, making voyages of astonishing length and settling in many lands, often driving out, or at least conquering, the original inhabitants of such lands. But ever as they wandered on, they bore with them the strange customs and sacred knowledge of their fathers. Though the loved Hawaiki had long since sunk down below the far horizon, yet did the hearts of the old sea-rovers turn to the west as of yore; albeit, as time passed by, the name of the shadowy fatherland was transferred to newer and known lands.

The Maori was in nowise behindhand in conserving the rights and records of the past. Though isolated in these isles for centuries, cut off from his northern brethren by a great stretch of ocean, yet has he preserved by oral tradition the legends, songs, genealogies, and sacred lore of the old-time people who roved to and fro on the vast Pacific in the days of the long ago.

One of the most interesting examples of the survival of an ancient Eastern ceremony was recently described to me by a native of the Ngati-Awa tribe, of the Bay of Plenty District. This was the wondrous fire walking feat—the strange, unexplained power, held by members of different races from India to Fiji and Tahiti, of being able to pass through fire, or walk barefooted over red-hot stones, without sustaining any injuries therefrom. This singular power was doubtless brought from the East in by-gone times by the pioneer ancestors of the Polynesian or Melanesian people, possibly by both, inasmuch as it obtains among both races at the present time.

STORY OF TE HAHAE, THE FIRE-WALKER.

In the time of Te Hahae and of Tikitu—that is to say, five generations ago—the Ngamaike people were living at Tauranga. And it fell upon a certain day that Te Rangi-kaku, of Te Awa-o-te-atua, went forth in his canoe for the purpose of fishing. And the winds arose, so that the ocean became violent, so much so that the canoe was upset and Rangi was drowned. His body was cast ashore at the entrance to Tauranga Harbour, where it was found by Ngai-te-rangi, who cooked and ate it. Te Hahae heard of this act, and calling his daughter Rere-wairua to him, he said, "Alas! my grandson has been eaten by Ngai-te-rangi. Go you to Puketapu, to your brothers, to Ouenuku and Rehe and Tikitu

Tell them to consent to this my request, that they prepare a plot of ground for the cultivation of the *taro*, that they prepare seventy *whawharua*, and cultivate, in each hole but one *taro*, which must be carefully cultivated, so as to grow large and fine."[2] So the *taro* were carefully cultivated, and grew to a fine size, while other kinds of food were also prepared, and the whole were presented to the people of Ngai-te-rangi. Then great quantities of firewood and stones were collected in order to cook the food in the native manner—that is, in steam ovens (*hangi* or *umu*). But the sacred oven in which the seventy large *taro* were cooked, that oven was reserved for Te Hahae to manipulate. Then that *tohunga* dug a hole in the ground—a large hole—and filled it with dry fuel, upon which he placed a number of stones. Then he obtained fire by friction, and kindled the fuel, and during the whole time he repeated certain *karakia* (invocations, incantations). When the fire had burned down to a fierce heated mass of glowing coals, and the stones were red-hot, then it was that Te Hahae walked into the *umu* and stood upon those stones amid the fierce heat, clothed merely in a *maro* (girdle) made of the leaves of the shrub known as *kokomuka-tutara-whare*. Though he stood a long time in the *umu* repeating *karakia*, yet was he not burnt or in any way injured by the fire, and the green leaves of which his girdle was formed were not even shrivelled or withered nor affected in any way.

Then Te Hahae came out of the oven, and taking the seventy *taro* he placed them in the oven whole—that is, without dividing them. They were protected from the hot stones above and beneath by green leaves, and he then covered the whole with earth, still repeating *karakia*. When the *taro* were cooked he took them out and presented them to the Ngai-te-rangi people, who had eaten the body of Te Rangi-kaku, and upon whom he wished to inflict a great punishment. During all this time he never ceased his incantations. Then the people of Ngai-te-rangi and Ngati-Pukenga ate those *taro*, after which they entered their canoes, and went out to sea to the fishing grounds to catch *hapuku* that they might make a return present of food to the men of Nga-Maihe. Then Te Hahae sent his tribe back to their homes, and he went down and stood in the waters, and there by his potent spells he caused the sea to rise, and also raised the fierce sea wind known as Uru-karaerae. Thus the winds came and the lightning and thunder and hail, and a great storm arose, which overturned those canoes far out upon the ocean. So the man-eaters of Tauranga went down to death.

The object of the fire ceremony in the above was to give *mana* (power, force) to the *karakia* of the priest. Unfortunately, my informant was not able to give me these *karakia*, and they are probably lost for ever. Some state that the above fire was known

as *ahi taitai.* My notes concerning the latter tell me that it was a sacred fire kindled by a priest, and at which certain ceremonies were performed and *karakia* repeated. It seems to have given force to the invocation of the priest. It was the *hau* or *mauri* (essence, spirit, protecting power) of the village home. In some cases sacred food, such as *kumara* (sweet potatoes) or a bird was cooked at the *ahi taitai.* A portion of the bird would be suspended over the sacred fire, and afterwards buried in the ground, where it would act as an *ika purapura* or *manea*—that is, as the essence or protecting genius of the people, the land, and the homes. By its subtle power witchcraft would be warded off and prosperity retained; the life of man was preserved by such means. *Manea* is truly the *hau* or essence of a man as well as of land or a village. Te Whatu, of the Urewera tribe, thus described it to me: "It is the essence or unseen spirit of man, and his footsteps are impregnated with it. Should you walk across yon plain, and should I chance to come upon your trail and extract your *manea* from your footsteps, and take that *manea* to my place and suspend it on the *whata puaroa.*[3] And then when the sacred *mara tautane*[4] is being cultivated I take the *manea* to that place and bury it in the earth, together with some of the seed *kumara.* It is then, O Son! you will pass from the world of life and know death."

When a party of natives chanced to be travelling by the coast-line through an enemy's country they would be careful to walk in the water, thus leaving no footprints, and rendering it impossible for any evil-disposed person to capture their *manea.*

The remaining portion of the bird, cooked at the sacred fire, was eaten by the priest. Should there chance to be no priest of sufficiently high rank present to eat that portion, then would it be placed upon a tree to be eaten by Tane—that is, as an offering to Tane, god of forests and birds.

Of a similar nature to the above is the *umu tamoe* or *umu taoroa.* Such a fire was kindled by a priest of the Tuhoe tribe after they had defeated the Ngati-awa tribe at Te Kaunga. The priest recited sundry *karakia* to "harden" himself, and then walked into the fire, where he stood and repeated invocation to his tribal gods to render the enemy powerless to obtain revenge.

The *ahi taitai* was in great requisition during the important ceremonies pertaining to the first fruits, offerings of birds and fish. The *rau huka* (leaves of various species of *cordyline* of which snares are made) were gathered, and some of them placed upon the sacred fire, while appropriate *karakia* were repeated to ensure many birds being taken. The *karakia*, known as *taumaha*, were then repeated in order to bring many birds to the tribal forests, and the first bird taken was spitted and roasted before the sacred fire. When cooked, the priest pulled the bird

off the spit with his teeth and ate it, still without touching it with his hands, but gnawing it as a dog would and spitting forth the bones. The bird may only be touched with the hands before it has been cooked. The balance of the first "take" of fish and birds are then cooked, and a third *karakia* recited to cause a plentiful season.

The term *hau* is applied to the home or to man as we have seen. It is the invisible essence of man, that spiritual portion of his being which controls his existence, but which, if it comes under the influence of a greater magician than himself, will assuredly cause his death. In like manner the *hau* of the home or of land must be carefully cherished and guarded from designing *tohunga* (priests, wizards) lest the tribal homes be lost.

The *mauri* of a forest or of a tribal home is the material object which represents the *hau*. It is imbued with the sacredness of the *hau*, and is the material token which absorbs, retains, and protects the same. The *mauri* is in some cases a stone. This sacred stone is carefully concealed, probably at the base of a tree frequented by bird snarers, for the powers of the *mauri* will cause many birds to flock to that particular tree. No one but a priest could discover the *mauri* of a forest—no common person could find it. A small platform (*kahupapa*) is erected among the branches of the tree to serve as a seat for the fowler. In some cases under this platform was kept *amoko tapiri*, which is a small lizard of a whitish colour and having a rough skin. Its duty was to guard the tree and the forest *mauri*. The *mauri* of the Rangitaiki River is a boulder in the bed of that stream, near Fort Galatea. At this spot the first eels of the season are caught. In other cases the *mauri* is something constructed of the long wing feathers (*kira*) of the *kaka* parrot. The feathers of the right wing only are used; those of the left wing have no *mana* (prestige, influence, power). This form of *mauri* is the one used to protect the *hau* of forests wherein bird-snaring is carried on. It is rendered *tapu* and efficient by the *karakia* of the priest, and its duties are to protect and multiply the various food products of the forest. Only one or two persons of the community were allowed to know where the *mauri* was concealed and how to preserve the *hau* of the *kainga* (village or settlement). Should the *tohunga* or priest of another tribe come with the intention of taking or destroying the *hau* of a *kainga*, he would not be able to accomplish the task should he fail to discover the *mauri*, which is the *aria* or *ahua* (incarnation, or material form or token) of the *hau*. The *mauri* also plays a part in the first-fruits rites of the Maori. The first fish of the season were taken to the tribal *mauri* of that sea and there deposited. The sea *mauri* of the Whanau Apanui tribe is a *rata* tree at the mouth of the Motu River. The first *kahawai* fish of the season were carried to that

tree and left there, certain invocations being repeated over them. Another form of the *mauri* was that of a hollow stone in which was placed a lock of hair or some other substance. The stone was then wrapped up and deposited at the base of a tree or by the side of a stream. The term *mauri* has many shades of meaning and different applications. If requested to travel or work immediately after a meal, a Maori will say, " Wait until the *mauri* of the food has settled."

When the aborigines of New Zealand first obtained the *kumara* (sweet potatoe) from the Pacific isles about eighteen generations ago, and the first crop thereof was gathered and placed in a store-house, then they slew Taukata, an ancient voyager who first made this food known to them, and sprinkled his blood on the lintel of the door of the store-house. This was to prevent the *mauri* of the *kumara* from returning to Hawaiki, whence the seed tubers had been obtained.

IHO TAMARIKI.

This is the umbilical cord, severed at the birth of a child, and connected with it were some singular customs. The *iho* of a chief's son was often placed under a stone or on a tree at the boundary of the tribal lands to maintain and strengthen the tribal influence over such boundary. The *iho* of children of many succeeding generations might be placed in the same spot. Several such places are known to me here in Tuhoe Land. The *iho* was sometimes placed in a tree, and that place would ever after be known as the "The *iho* of So-and-So." At Te Ariki is a tree in which the *iho* of a priest's child was placed, and the hole closed with a piece of precious greenstone. This latter addition enhanced the *mana* of the *iho*. Te Iho-o-kataka is the name of a famous *hinau* tree which stands in the Upper Whakata Valley, near unto Ohaua. It holds an important place in the annals of Tuhoe Land, inasmuch as it possesses the singular power of rendering barren women fruitful. It came about in this wise:—When Kataka, the daughter of Tane-atua, was born some seventeen generations ago, Irakewa took the *iho* of the child when severed and placed it on a *hinau* tree at Ohaua. And it chanced that Tane-atua, travelling to the interior, sat him down to rest beneath that tree and stretched forth his hand to pluck some berries therefrom. What was his surprise to hear a voice say, " Do not eat me, for I am the *iho* of Kataka, your child." So it came about that Tane-atua rendered that tree *tapu* for all time, and also endowed it with strange powers by means of suspending thereon the *iho* of another of his children and uttering these words : "I am here suspended that I may cause children to be conceived." And ever since that time has that tree held the

strange power of causing children to be conceived; and when a woman proves to be barren she proceeds to that tree, and by embracing it she may become fruitful. She is accompanied by a priest, who, during the performance, repeats the necessary invocations. One side of the tree, that towards the rising sun, is known as the male side, and that facing the setting sun is the female side. The sex of the child is determined by the side embraced by the would-be mother.

When the *iho* of a child was severed and the end thrust back, then certain *karakia* were repeated in order to dispel ignorance from the mind of the child as it grew up, and to give it a quick understanding.

URUURU-WHENUA.

This is a ceremony performed by a person who, for the first time, ascends a mountain, crosses a lake, or enters a district never before traversed by him. The term implies "to enter or become of the land." It is an offering to the spirits of the strange land. It is generally performed at a certain tree or rock situated on the trail by which travellers pass into the district. Every person on passing such places for the first time would pluck a twig or piece of fern and cast it at the base of the tree or stone, at the same time repeating a short invocation to the spirits of the land. After passing on such a person would never look back towards the tree; it would be an evil omen were he to do so.

OMENS AND SUPERSTITIONS.

Their name is legion in Maoriland. It would appear that at no single moment during his life was the Maori free from the harassing and appalling array of evil omens, unlucky acts and words which might well have kept him in a constant state of nervous dread. Not even during sleep was he free from such, and good or even fortune was betokened by the movements of the limbs, twitching of the muscles, and other things equally absurd.

Examples.—If a traveller should see a lizard in the path before him, he would know that the creature did not come there of its own accord but had been sent by an enemy as an *aitua* (evil omen) for him and to cause his death. He, therefore, at once kills the reptile and gets a woman to step over it as it lies in the path. By this means the evil omen is averted. And he will also probably cast about in his mind to discover who the person or persons were who sent this dread object to bring misfortune to him. Then he will say, "May so-and-so eat you." Thus he will transfer the *aitua* to that person so named.

To sleep frequently in the daytime is an evil omen. It is known as a *whaka-waikokomuka*. To prepare fernroot for food during the night is also unlucky; and to pass before a priest is a serious and dangerous thing. If people of a village collect in the *marae* (court-yard, open space) and sing a *puha* or derisive song without due reason, that act is a *taputapu-ariki* and betokens trouble to come. To camp on a battle-field after a fight is unlucky, and is termed a *whakaupa*. To hear the chirping of a *moko-ta* lizard is also an *aitua* of fell meaning. The evil omen known as *Irirangi* is a spirit voice heard singing without, when at night the people are within their houses. That termed *miti aitua* is a dryness of the throat which assails warriors when in battle. The adverse omen known as a *korapa* also pertains to war. It is when a man does not keep time in the war dance, or does not leap so high as his comrades. As also when a challenger, in defying the opposing war party, looks behind him towards his own people. Again, if in battle a warrior spares the life of the first foeman vanquished by him that is a *pahunu* (an evil omen), for he will surely be assailed by *Tu-mata-rehurehu* (Tu, "the dim-eyed;" Tu, is god of war) which means that both his sight and courage will be seriously affected, and the sight of the enemy will cause him to tremble. It is also a *pahunu* to eat of the food left by the first-born of a family. The only cure for this dire affliction is for the unlucky person to seek out the first-born female of a family and get her to step over his body, which act breaks up the *pahunu*.

Kotua.—If in travelling to a village I meet a person who informs me that a relative of mine is dead at that place, and should I turn back at once, that is a *kotua* and an evil omen for me.

Whakarapa.—This is when a member of a plundering party stands idly by while his companions are busy loading themselves with booty; or when, in travelling, one refuses to stop at a village when invited.

Kopare.—Should I chance, while carrying food, to meet a friend, and should I pass on without speaking lest he ask me for some of my food, that is a *kopare*, an evil omen for me, on account of my churlishness.

Tawhanga-rua.—In cooking birds in a native oven (*hangi* or *umu*) if, when the oven is opened, the birds are not quite cooked, do not on any account cook them a second time (*tawhanga-rua*) for that would cause all birds to desert the adjacent forest. This is a law of Tane, the god of forests and birds, for these are his children.

Rua koha or *rua kanapu*.—This is summer lightning seen playing about the summits of mountains during fine weather. It is a good

or evil omen, according to the direction in which it darts. The *rua koha* would appear to have been observed in ancient Rome. It was the evil omen which portended the defeat of the Roman legions under Varus by Arminius, the War-man of the North.

Puhore.—There are many items which come under this heading. *Puhore* means to be unsuccessful in fishing or hunting, &c. One of such items is the *toitoi-okewa.* Should a native be about to go out hunting, and should he speak of an animal or a bird as already secured, that is a *toitoi-okewa*, and the hunter will be unsuccessful. Reduced to plain English it means, "Don't count your chickens before they are hatched," which is an Anglo-Saxon *puhore.*

When engaged in digging for the edible root called *perei*, no digger may mention the name. If anyone desires to speak of the object of his search, he will term it *maukuuku*, for should he mention the name *perei* no roots would be found by the party. In the bird-snaring season should a man mention that he is going to visit his snares in order to take the birds which have been caught, he will not make use of the word *wetewete* (a plural form of *wewete*, "to untie"), for that would be a *puhore.* He will use, in place thereof, the term *wherawhera* (a plural form of *whera*, "to open"). Or should the snarer be going to look at his *waka* or water troughs, over which pigeon snares are set, he will not use the word *titiro*, "to look at," but substitute that of *matai*, that no *puhore* may be incurred.

Such illustrations as the above might be carried on indefinitely by anyone who cares to collect the necessary material from the older generations of Maoris now living. From my limited knowledge of the subjects it appears to me that the unhappy Maori of pre-*pakeha* days was simply hedged round by an appalling array of evil omens, *puhore*, laws of *tapu* and *rahui*, with other products of superstition and ignorance. Such superstitions and customs are, however, extremely interesting, and it is to be hoped that we of this generation will endeavour to place on record the customs, language, traditions, and mythology of the various Polynesian peoples before it is too late. A comparative study of such, together with those of the Asiatic and Indonesian races, would certainly lead to interesting results, and open up a vast field of research for future anthropologists.

With the Maori of New Zealand the time is rapidly approaching when the men of knowledge will be no more, and the last *tohunga* shall pass downward through the surging seaweeds of Te Reinga to the grim underworld of the Goddess of Night.

NOTES.

(1.) *Whawharua.*—Holes in which *taro* are planted. These holes were of two kinds—(1) The *whakarua-kawau*, a deep hole in which the *taro* grew in an elongated form—(2) *Ipurangi*, a shallow hole in which the *taro* grew round and compact.

(2.) The reason for allowing but a single *taro* to grow in each hole was that it might grow large and thus be capable of giving force to the *karakia* (incantations) which were to be repeated over them by the *tohunga* (priest), Te Hahae. When the *taro* were formed on the root, the hole was opened and all but one taken away, as also many of the rootlets or fibres. The old leaves would be taken from the plant and placed in the hole around the single *taro*, and the hole again filled up. Thus all the vigour of the plant was expended in the production of one fine *taro*.

(3.) *Whata puaroa.*—This appears to be some sacred portion of a priest's house or place used as an altar.

(4.) *Mārā tautane.*—A small plot of ground in which is grown the *kumara* set apart for the gods, *i.e.*, the first fruits.

No. 4.—PICTORIAL ART OF THE AUSTRALIAN ABORIGINES.

By R. H. Mathews, L.S.

(*Read Friday, January* 7, 1898.)

No. 5.—AUSTRALIAN INITIATION CEREMONIES.

By R. H. Mathews, L.S.

(*Read Friday, January* 7, 1898.)

No. 6.—THE DIALECTICAL CHANGES OF THE INDO-POLYNESIANS.

By Rev. S. Ella.

(*Read Saturday, January* 8, 1898.)

No. 7.—LIFE HISTORY OF A SAVAGE.

By the Rev. GEO. BROWN, D.D., Sydney.

Read Monday, January 10, 1898.

I PURPOSE in this paper giving a brief outline of the everyday life of a savage from his birth to his death. His life as compared with the busy exciting life of a man in these colonies in this present 19th century civilization may perhaps be thought of little importance, but no type of human life can be considered uninteresting or uninstructive to the student of anthropological science.

The life I am about to describe is that of a man born in a part of the New Britain Group, situate in about 4° S. lat. and 153° E. long. His parents were members of one branch of the great Papuan family and had their home in the midst of a dense bush—not far from the beach, however, for all the coast natives live in dread of the bushmen. The village in which they lived was not laid out in streets, nor were the houses built together on one site. A New Britain village consists generally of a number of small communities or families, their houses being built together in small clusters and separated from those of other similar communities by patches of uncleared forests through which run irregular and very often muddy foot tracks, scooped out in some places by ease-loving pigs into mud-holes in which they can wallow and enjoy themselves during the heat of the day. These sites, however, are kept scrupulously clean, and it is always easy to tell an old village site by a circular mound in the bush caused by the accumulated sweepings of dead leaves and rubbish.

The houses are all very small and very poorly constructed. They are generally oblong in shape and very low. In olden days there was often a rattle suspended in the doorway at night against which anyone attempting to enter in the night would hit his head and so arouse the inmates. This was done as some protection against surprise and treachery. The furniture in the house in which my friend's parents lived was neither large nor varied. It consisted of a few bamboos along one side, raised a little from the ground so as to make a kind of bench or seat, a plank from some old canoe, which served as a kind of bed, a fishing net, some spears, and tomahawks, a few baskets of yams, green bananas and edible nuts called tamap, and a few cocoanuts. There were also a few water bottles and a basket or two containing lengths of native money called diwara, beads, pipes, tobacco, net twine, betel pepper

and areca nuts, and a gourd or bamboo box containing lime to eat with the areca or betel nut. It might all be summed up as follows: a man and woman, a house, a fire, a board or leaf to sleep on, a few baskets of food and a few weapons. Outside these clusters of houses, however, would be seen evidences of taste and appreciation of the beautiful in the planting of dracœnas, crotons, and coleus plants of the brightest colours.

In such a place and amid such conditions the man of whose life I am to give a brief outline was born, and in order to make my account more definite and clear than it would be if I dealt with him simply as an imaginary being, I shall take the liberty of naming him at once by the name which he will bear through life so far as this account is concerned, though in doing so I am doing what his own father and mother would not have done themselves, as a man is rarely if ever known by the same name from childhood to old age. I shall call him Tepang, which literally means "my friend."

HIS BIRTH AND BOYHOOD.

At his birth the father would have to clear out, but so far as I know, there would be no particular ceremonies observed except paying the women who came to nurse the mother. He would get first a little of the expressed juice of the cocoanut to drink, and would be clothed only in a warm banana leaf, and probably carried for a day or so on the sheath of the cocoanut blossom. They make no fine mats, and only small and very coarse pieces of native cloth from the bark of the breadfruit where Tepang was born, and so his dress was simply the sunshine in the beginning and a certain quantity of ashes and dirt when he began to crawl about.

As a boy he lived and acted much as other boys do in more civilized communities. The games in which he and his comrades played are many of them very like our own, together with some others peculiar to them. He and his playmates often built houses on the beach or away out in the shallow waters of the lagoon, and got more pleasure from living and sleeping there than they did in their own homes. Then there were often sham fights in which reed spears were used in place of the more dangerous ones used by the grown up men, and in these fights they acquired a skill in throwing which was very useful to them in after life. In the day there were fishing, boating, and bathing parties, and at night there were songs and dancing, and in many other respects they aped the doings of their seniors. Tepang would work only when it pleased him to do so. If his father or mother told him to go to the garden and he did not wish to do so, he simply ran away to the beach or to the bush and came home when he pleased. He got his share of the regular evening meal, but the most of his

food he picked up when and where he could. He was, however not allowed to eat some things, notably the cuttle-fish, which they say runs backwards, and so a boy eating that is sure to grow up to be a coward.

HIS ENTRANCE INTO LIFE.

As Tepang grew up his parents were very properly anxious that he should become a member of the secret societies, and so steps were taken for his initiation. The first probably of these societies into which he was admitted would be the Dukduk. Many considerations no doubt influenced his parents to take this step (1) The Society is a powerful one, and there is a certain amount of prestige in belonging to it. (2) Many of their son's comrades were members of it, and Tepang would certainly make trouble if his parents did not find the money for his entrance fees. (3) He would certainly be fined sooner or later for some real or imaginary breach of the Dukduk's laws, and as they would have to pay the fine it was cheaper to pay the fees. (4) There was always a certain amount of plunder obtained by the Dukduk, and they naturally wished for Tepang to have a share. The Dukduk is a society of men whose principal object is to extort money from everyone else who is not a member, and to terrify women and those who are not initiated. They have a "sacred" piece of land called the "tareu" in which their house or lodge-room is placed. Here the dresses of the Dukduk are prepared, and from this place the Dukduk go out whooping and dancing to terrify or amuse the people. Here also the members congregate all day long whilst Dukduk operations are in force, and gossip, eat, and sleep to their heart's content. No woman nor uninitiated person dare go near this sacred enclosure. The Dukduk is represented to the outside public by a figure dressed in a full leaf girdle, composed of rings of leaves strung together extending from the breast to below the knees. These when shaken as the figure dances increase the awe with which Dukduk is regarded. The upper part of the body is covered by a high conical mask gaily ornamented, made of wicker work, and covered also with leaves or cloth. This extends down over the shoulders and arms and rests upon the leaf girdle, so that the whole of the man's body is covered with the exception of a part of his legs. He often carries a spear or stick, and sometimes also a human skull in his hands as he goes whooping and dancing along the paths. Often two or three Dukduks emerge from the "tareu." The women and boys all hide as these figures go along. They are supposed to believe that the Dukduk is a spirit from the bush, and they very wisely pretend to do so. Some of these Dukduks have only a short black mask instead of the gaily ornamented one. These are the females who give birth to the Dukduk proper.

When Tepang first sought admission he became a "tena-mana" or candidate, and certain fees were paid, then he and his fellow-candidates were put through an elaborate system of fooling, and had to suffer some actual pain in their supposed search for the Dukduk. After passing through the preliminary fooling they became "tena-wanai" or apprentices, and had a little more insight given them, and then, after a while, they became "tena-maul," or fully accredited members, and learnt all the secrets. These were principally how to prepare the dresses, what to say, how to dance, and what were the restrictions as to food and conduct whilst the mysteries were engaged in, and above all how money was to be made and food procured from other people by the fear inspired by the Dukduk. It must be said, however, that this association had its own sphere of usefulness in a state of society such as existed in Tepang's birthplace, where there were few chiefs of sufficient power to compel any obedience to law or to enforce punishment against a transgression except by the aid of such a society as the Dukduk.

As Tepang grew up and either found money himself or was provided with it by his friends, he was initiated into other societies, all more or less secret. In one he was taught how to curse his enemies in the most telling manner; in another, how to prepare love philters for his own use, or for the use of those who paid him for them; in another, he was shown the secrets of "Agagara" or witchcraft, and taught how easy it was to make a man sicken and die just as he pleased. He was taught how to make new dances and how profitably he could sell them to other towns. He also became a member of the Iniat Society, and after the months which were passed in the ceremonies of his initiations were completed he could never again eat pork, shark, dog, or turtle, and he always had to have his food cooked in a separate oven for fear of contamination from any of those forbidden delicacies. From all which it will be seen that it is a great mistake to imagine that a young man in Tepang's position had no duties or responsibilities such as we have here, that he had nothing to do but eat, sleep, and be merry, or that he had no taxes to pay or any public duties to perform.

HIS MARRIAGE.

It is, however, quite time that I said something about my friend's marriage. People in New Britain marry as they do in other places but they are not "given" in marriage, for there is always payment made and received. There is, indeed, a fine distinction in their language with regard to the preposition used, as a man marries "with" the woman, but the woman marries "to" the man. When Tepang, like other young men, thought it was

necessary for him to have a wife, he found himself at once involved in a maze of long-established customs and usages, amid which it was impossible for him to find his way alone, and so he had to submit to the guidance of those who knew better than he did how to act. He knew, of course, that he must select the lady from the opposite class to his own. In his land, men and women, boys and girls, cocoa-nuts, fishing stones, food-bearing trees, &c., are all divided into two classes, one called Pikalaba, and the other Maramara. No Pikalaba can marry one of the same class, and Tepang being Pikalaba, could only marry a girl who was Maramara. Marriage with a girl of his own class, though no blood relative, would be considered incestuous, and would have brought speedy punishment; in fact, the whole of the people would have been horrified at such an event. When he fixed his affections upon the girl he wanted for a wife, the first thing to do was to find out whether the girl liked him or not, and this was the first difficulty, for young men and young women do not mix together as they do in other lands. When I asked him how he found out whether the girl liked him or not without his having asked her, he said very innocently, "Oh, I saw it in her eye." He then told his relatives, and they agreed to buy the girl, for a man never buys his own wife, though he has ultimately to pay for her. When all was arranged, Tepang and his wife became "webat"—sweethearts or engaged. He then gave his betrothed what is called a Ka-na-ongrat or betrothal basket, answering to our engagement ring. In this basket he put some diwara, native money, beads, tobacco, armlets, shells, cuscus, teeth, with other property. He gave her this very quietly, or if too modest to do it himself he got some girl friend to give it. The girl could not, however, make use of any of the property in the basket until after their marriage, as she had to take it all with her on her wedding day, and show that she had taken all proper care of it. When it was known that the girl had received Tepang's ka-na-ongrat, no other young man could seek her without causing a great quarrel. After this, Tepang's friends borrowed "pupulu" money from some chief or "pet-palig" man of wealth, and on a certain day they divided this out amongst the girl's friends and relatives, whilst the friends of the girl brought food. During this time Tepang was invisible. He had cleared out of the village and hidden somewhere in the bush, as he was not supposed to know what was being done. The girl's relatives who had got the money were not allowed, however, to use it until all the ceremonies were complete. On a given day all the friends of each party made a display of their diwara and other property amid a great blowing of conch shells and shouting. This was to show the young couple what wealthy relatives they had. On another day all the diwara which had been given to the girl's relatives was brought back again, and each man who had

received any had to show it and then give back half of it to the bridegroom. After this, there was other interchanges of food between the relatives on either side, all regulated by strict rules, each basket having its proper place in the display. After this, the girl remained with her husband, but like a good girl she cried a good deal, and made a pretence of running away. Then presents were made to the young couple by their friends. The bride received some diwara "that she might get more diwara," some pearl shells "for knives with which to prepare the food," leaf dishes "for plates for her husband's food," stones "for the native oven," water bottles, bowls in which to prepare her puddings, a broom "with which she was to keep her house and grounds clean," and other articles too numerous to mention. Tepang received a spear with which he was to protect his wife, and also a stick as an emblem of his authority with which he was to thrash her in case she failed in the discharge of her duties. After this a chief, one of Tepang's relatives, came on the scene, having a club in one hand and a young cocoanut in the other. He first broke the cocoanut, and poured the water over the heads of the bride and bridegroom. Then he took his club and struck a banana stem as many blows as he had killed enemies in fight. This was to assure them of his protecting care over them. The final act was that Tepang had to repay the money which was borrowed for the purchase of his bride, with 10 per cent. added for interest, and so he became a married man. He made a good husband so far as he understood his duties. He cleared the ground for the garden, and made the fences, but left most of the planting to be done by his wife, and she had also to carry home the food whilst he walked behind with his spear or tomahawk only. She had no trouble about taking care of his clothes, simply because he never wore any. His wife had all the cooking to attend to, though he would occasionally help her, and would indeed cook for himself rather than go without his supper, if the wife was unable to do it. He was very fond of his children, and generally allowed them to do as they pleased, as he himself had done when he was a boy. The time allotted will not allow me to give all details of Tepang's every day life after this, and I can only briefly sketch his social, political, and religious life.

SOCIAL LIFE.

In his social life he had many duties to perform, and many engagements in which he had to take part. He had to take his place in the great fishing and trading parties organised by his people; he had to give feasts, and to join in the feasts given by others. When he was not engaged in the Dukduk ceremonies, or in those of some other society, he had to practice the songs and

dances in which his village was engaged. As a man who knew the different forms of witchcraft, his services were often secured by some one who wished either to kill or to extort money from someone else. To do this he would secure a piece of yam, banana, areca nut, or anything indeed which had been touched by the obnoxious party, or which formed any part of his body, such as hair, skin, blood, or indeed almost anything. Tepang would then take this and bury it in a hole in the ground together with small pieces of sharpened bamboo and poisonous plants. He would then utter some incantation over the lot, and would probably specify the particular manner in which he wished the misfortunes to fall upon the man. Then he would cover all up, and perhaps place some sacred stone of the Iniat Society upon it, receive his fee, and go to his board bed with a clear conscience, fully assured that so long as that spell was not removed its power would be felt, and until that stone was removed the man affected would be pressed down by disease, and nothing that he did would prosper. Of course, it soon got known that the agagara had been made, and if the unfortunate fellow concerned was not sick he soon got sick from fear, and the consequence was that he had to come and pay Tepang diwara in order that the spell might be removed. This was one of the ways in which my friend began to make his money, and develop into a capitalist, for nearly every native believes when he is sick that someone has bewitched him. Death, in the opinion of those people, rarely, if ever, happens from what are called natural causes. Tepang was also a doctor. In the course of his education he had been taught the medicinal properties of many of the plants and vines which grew in the bush, how to prepare them as medicine, what quantities of each he might safely use, and above all the proper prayers which were to be said if the remedy was to be successful. He was very skilful in the preparation of decoctions of leaves, over which certain prayers to the spirits of the dead were uttered. The patient's body was then carefully dusted with lime. Then Tepang uttered more prayers over the medicine, which the man at once drank, so that he might get the full benefit both of the medicine and the prayers. The lime was then blown off the body of the patient, taking (so Dr. Tepang informed them) a good deal of the disease with it. When he got a patient with plenty of money my friend would vary the latter part of the cure. In order to drive the disease away, and also the evil spirit who caused it, Tepang would prepare a steam bath by mixing in a large bowl a lot of cocoanut juice, burnt cocoanut kernel, ginger roots, and leaves of various plants and trees. The patient was seated over this bowl and covered up with broad leaves. Then hot stones were put into the mixture, some were also put under his feet, and he had to hold two others in his hands, and so he

was thoroughly steamed. Afterwards the doctor (Tepang) had a great feast prepared for the patient and his friends, for which the patient had to pay liberally, in addition to the doctor's fees. In this way also my friend added to his wealth. In addition to these professions, he was also a debt collector. Being a man of power, and having plenty of money, he was often appealed to by those who were unable to collect the debts due to them, or, what amounted to the same thing, the amount which they considered to be due. A. owes B. 10 fathoms of diwara, but refuses to pay, or B. cannot wait longer for the money. He goes to Tepang and presents him with 1 fathom, and then Tepang pays the 10 fathoms which A. owes, and A. in his turn has to give Tepang 11 fathoms, so that Tepang gets double commission, and nets a clear 20 per cent. on the transaction. In more serious matters Tepang got still higher commission, as he incurred more risk, and might have more difficulty in arranging the affair. A. commits adultery with B.'s wife. This is a very serious matter, and B. and his friends at once fight with more or less success. But B. has another remedy, and he takes, say, 10 fathoms to Tepang, who at once gives him 100 fathoms in return—that is, 10 fathoms for each fathom given him—and then he demands from A. 120 or 150 fathoms in return, which A. must at once give, or be prepared to fight the combined forces of Tepang and the aggrieved B. and his family. In these and other similar transactions, such as providing the money with which to purchase a wife for one of his friends, advancing the cost of a canoe or house, etc., Tepang became a comparatively wealthy man, and was always ready to lend on good security, and at a good rate of interest. Strange as it may appear, these people have words for getting goods on credit, for borrowing, lending, pledging, redeeming, and also one for interest, and Tepang regularly lent out money at rates never less than 10 per cent. In this matter Tepang was very like some people who are in a much higher stage of civilisation than that to which he had attained ; but in another custom he was very much at variance with them, for he was an undoubted cannibal, and what is more, he saw no harm whatever in the custom, but on the contrary he regarded it much as a religious duty and at all events as being a very commendable act. The principal motive which actuated Tepang in eating his enemy was that of revenge and giving rest or satisfaction to the spirit of his relative or friend who had been killed. I do not think that the desire in his case, at all events, was from a craving for animal food or from the idea of acquiring, by eating his enemy, any part of the valour or strength of the person eaten. When Tepang or his friends captured or killed an enemy they bound him securely and took him to their village and made all kinds of taunting speeches to him. They showed him the house and grounds of the

man whose death they were revenging. "Look (they would say) you are the man who killed So-and-So; see, there is his house, these are his weapons; these trees belonged to him; this is his garden; now we are going to eat you in payment for what you or your people have done." If the man were living he would answer these taunts, either admitting them or denying them, and saying who it was that had done the deed. Sometimes, in such a case, some friend of his would produce a large quantity of diwara and ransom him, but in most cases he was killed and eaten.

This illustrates the idea of revenge as the inducement of cannibalism. The other idea is shown by another example. One of Tepang's relatives is killed, and, of course, there is no rest for his spirit until proper satisfaction is given. His house is kept in order, his spears are stuck in the ground in front of the house, and his tomahawk is hung on the wall. A dead branch of a tree is stuck in the ground in front and a small basket is hung upon it in which Tepang and his friends put small pieces of food from time to time. In course of time they either kill the man who killed him or one from the same village, or failing that they buy such a man or a piece of one from some other village. Then the family of the murdered man assemble and each one eats a small piece of him, another piece is put in the basket, which I have mentioned as being hung near the dead relative's house, and another piece is flung in the direction of the village of the man who killed him. The piece which is put in the basket of the dead relative is to assure his spirit that his death is avenged and that he may now go away in peace. Tepang and his friends then pull up the spears, take down the tomahawk, uproot the dead branch, let the house go to ruin and go to their ordinary business quite satisfied that they have done their duty. The skulls of these victims, however, are often kept as trophies and may be seen stuck up on poles, either in front of Tepang's house or on the spot where his relative was killed. In some places the jawbones are kept, and I have seen in one house thirty-five of these relics hung up on the battens of the house.

OF TEPANG'S POLITICAL LIFE

I can say but little in this paper. As a man of influence he had to take his part in all the deliberations regarding taboos, and help to enforce the penalties which followed any breach of the laws. This institution, however, is not so far reaching nor so frequently used as it is in other groups. He had also to take his full share of all the fighting, which is frequent enough to satisfy any man. Tepang and his people were always at feud with neighbouring towns and villages. Sometimes peace would be made, and there would be a settling up of all the differences; but this state never

lasted long, and some new cause of offence would revive all the old, bad feelings. When one town decided to fight again, they would often send a notice to that effect, and the others would meet them at the boundary between the two villages ; and Tepang, of course, had to be present, for all must go.

He and his people fought with sling and stones, spears, and tomahawks, and in later days with the white man's musket. There was never much execution done in these fights. If one man on either side got speared, that was considered quite enough for that day, and both sides would disperse. After this there was but little to do except to guard against surprises, for the war assumed a chronic state, and each side simply tried to surprise some unfortunate individual when off his guard. Before Tepang went to any of these fights he had to bathe and offer prayers to the spirits, asking them to make the tomakawk sharp and the spear good. When he got to the boundary he, as a man of knowledge, had to taunt his adversaries with all the foul language he could hurl at them, and as he knew a good deal of bad language he could do this pretty effectively. Then he knew many poisonous plants, and also a poison which he obtained from the sea, probably from some sea anemone, and with these he anointed his spear, and also those of his friends, to make them more deadly ; but as I have said, not many people were killed in fair and open fight.

Peace-making, however, was a very complicated matter, and many ceremonies were observed. When Tepang and his friends desired to make peace with those with whom they were at enmity, they first sent a dracœna plant as a sign of their wish. If the other chief was favourable he accepted the dracena and planted it in his ground. Then he pulled up one from his own ground and returned it by the messenger. After this, negotiations were entered into and a day fixed for the settlement. On the appointed day Tepang and his people assembled on one side of the appointed place and the other chief and his party occupied a position opposite to them. All were armed as if for fight, and at a given signal they advanced, brandishing their spears and shouting defiance to each other. Then they rushed madly against each other with spears poised ; but as they met each man turned his spear aside and turned his shoulder to his opponent, and they bumped together. This was done several times, first one side and then the other being the challenging party. After each bumping, small pieces of diwara were interchanged. Then Tepang made a speech, in which he laid all the blame of the wrongs which had been done on some member of his village, and assured his opponents that the evil was committed without his consent. The other chief replied in a similar manner, laying all the blame on someone who was dead. Then Tepang and his people tied a lot of money on a large branch of a tree and cried out, "This is for So-and So," mentioning

the name of someone of the opposite side whom they had killed. As soon as the other side saw this they appeared to refuse it, and advanced as if to fight, but finished, as usual, by bumping shoulders together. They took the money and were carrying it away, when Tepang and his friends pursued them as if to regain their property. This, however, was only a pretence, and ended, as usual, in the curious bumping ceremony. The other side then brought payment for one of Tepang's friends whom they had killed, and the same scene was enacted; and so on alternately until all the killed on both sides had been paid for. Then there were large quantities of food brought by both parties, more sham fights, and more bumping. The food was all mixed together, to guard against any witchcraft and to show that no poison had been put in. After this, Tepang and his friends rose, yelling and shouting, and circled round the food, and the other side did the same, and Tepang and his party finally sat down on the side which had been previously occupied by the opposite party, whilst they sat on the spot where Tepang and party had been, and so peace was made. During these ceremonies there were also several symbolic actions, such as darting a spear apparently at one of the opposite party, but burying the point in the ground instead; and also when one man from either side advanced as if to fight, but instead of hurling their spears, each man put his foot on his spear and broke off the point by a sudden twist of the hand.

SICKNESS AND DEATH AND BURIAL.

As Tepang got old he was often sick, and at such times all the spells which he had been accustomed to use to others were tried, with varying success. Sometimes he was better, but as months went on, both he and his friends saw that his strength was declining. During all this time his friends were very attentive to him, for they never desert the sick.

At length, the old man felt that the end was not far away; that all spells had failed, and he must prepare to die. He then told his friends what he thought and what he wished. He disposed of part of his property, but the bulk he left to be divided according to native custom. His friends then made a litter for him, and on this the old man was taken to all the old familiar places where his life had been lived, that he might see them again for the last time. They took him to the tareu, and to the lodge-room where he had been wont, year by year, to take part in the Dukduk ceremonies; to the house where his canoes were and where his nets were hung, which he would never use again; to the garden which he had fenced; to the trees which he had planted; to the boundary where he had often fought; and to the

houses where his friends and relatives lived; and then, weary and tired, they took him home to die; and when he passed away, they mourned for him with loud and bitter wailing, varied with curses against those who had caused his death.

Tepang being a chief was not buried at sea as other and poorer people were. A chair was made, called a koromia, and on this he was seated. He was then bathed. After this he was decorated with necklaces, wreaths of flowers, and feathers and decked out in full war paint. Then they put a spear in his right hand, his club was put over his shoulder, and some ginger plants in his mouth, the mask of a warrior and a large cooked yam were put in his hand. They gave him his weapons that he might fight his way against any who tried to hinder him from going to the spirit land, matana nion, whilst the food was for him to eat on his long journey. There was, of course, the usual jumping-off place for all spirits, but it was often difficult for them to get there. The friends and relatives then brought coils of money (diwara), necklaces, ornaments, &c., and placed them in front of the dead chief, and before taking them away they broke off small portions on the fire which was burning there. Tepang's spirit was supposed to take all this property (the spirit of it) to spirit land and so enter there as a rich man. After this certain ceremonies were performed to find out the name of the evil spirit who had caused the death, and also to find out the man who had bewitched Tepang, and got the evil spirit to compass his death. Tepang was then placed on a platform, and, whilst the process of decay went on, the relatives sat round, regardless of the stench, as they thought in so doing they would get some of the dead chief's courage and knowledge. Some of them would even anoint their bodies with the dripping from the platform for the same purpose. When the head became detached it was carefully preserved by the nearest relative, whilst the body was buried in a house at a very shallow depth. A fire was made on the top of it, and the relatives slept in the house. All the relatives blackened their faces for a long time, and afterwards the skull was put on a platform and dances were held round it for many nights. Up to this time Tepang's spirit was supposed to be somewhere about, but after this he was not to trouble them any more. They had done all they could for him, and as a properly-behaved spirit he should now keep to his own place. Where that place was they did not know. The spirits of common people were supposed to stay about the caves and holes in the rocks and to eat rubbish, but those of men like Tepang, who had been a warrior and, above all, a generous man, went to a good place and were well fed. The only definite punishment I ever heard of was in the case of a niggard, and the punishment of such a man they told me was that the spirits took him and bumped him against the big slab roots of the chestnut tree.

I have now given this short sketch of some of the incidents and experiences in the life of my friend, but it is impossible to give in the time allowed for this paper all the life history of a man who lived as long as he did, and I can only hope that at some future time I may be able to complete this very imperfect sketch.

No. 8.—THE DISAPPEARANCE OF NATIVE RACES IN GENERAL, AND OF THE FIJIANS IN PARTICULAR.

By H. H. Thiele.

(*Read Monday, January* 10, 1898.)

No. 9.—NOTES OF A RECENT JOURNEY TO NEW GUINEA AND NEW BRITAIN.

By the Rev. Geo. Brown, D.D., Sydney.

(*Read Monday, January* 10, 1898.)

The visit of which I purpose giving a short account was begun in May last and extended to the middle of September. The course followed was from Sydney to Port Moresby in New Guinea, thence to Samarai, the Engineer Group, the De Boyne Group, the d'Entrecasteaux Group, the Trobriands Group, New Britain, Duke of York, and New Ireland. I sailed from Sydney as far as Samarai, in New Guinea, in the s.s. "Titus," and from there voyaged either in open boats or in a small 14-ton ketch until we reached Cooktown on the return voyage.

During the period of my journey I saw a good deal of the natives, and had also the advantage of constant intercourse with the missionaries, and also with the Samoan, Fijian, and Tongan teachers who are resident amongst them. Most of my information as regards the habits and opinions of the New Guinea peoples was obtained from the Revs. W. E. Bromilow and S. B. Fellows.

New Guinea and its inhabitants have been so often described that it is not necessary to dwell at any length upon them. The country presents the usual features of high mountainous land in the tropics, whilst the people, who are members of the great Papuan family, are in somewhat different stages of culture, from the naked savages of the western portion to the more civilised races who inhabit the south-eastern groups of islands and the extreme east of the mainland.

The principal products of the islands are pearl-shell, beché de mer, copra, and rubber. Gold also is found both on the mainland and in the islands —from which latter the principal amount has been obtained. There is little doubt, I think, that rubber will, at no distant date, be the principal article of export. It is obtained from large trees by boring, and also from several species of vines —the latter being the best in quality.

I have visited New Guinea on three different occasions, and I noticed very great changes in the social position of the people which had taken place since my last visit in 1891, some six years ago. The influence exerted by the Government and by the Missionaries was very apparent in the change which has taken place among the people. I noticed particularly that the people travel far more now than they did, because they can go in safety ; this is of great benefit to the natives living on many of the islands as they can now purchase food during the months of scarcity and so they live better than they did previously. Another benefit is that the coast line is becoming more settled. Formerly the bush people were afraid to live there from fear of the large tribes living on either side of the unoccupied district, whilst the people of those districts, and those of the neighbouring islands, were afraid to settle on them from fear of the bushmen. Now, large portions of these coastal districts are being settled, and villages are being established in districts which were quite unoccupied on my previous visits.

I was not able to make many notes in the Engineer and De Boyne Groups, as my stay in those islands was very short. The people in De Boyne Group (Panaieti) are great canoe builders, and some of the finest canoes in south-eastern New Guinea are built there.

At Dobu (Goulvain Island) in the d'Entrecasteaux Group ,I made a longer stay and found that great changes had taken place there since my last visit. The skulls of enemies, who had been killed and eaten, which used to be placed in rows over the doors of the houses had all disappeared. The dead, who were formerly buried in the villages close to the houses, are now all buried in a general cemetery at some distance from the villages and the social position of the people is much improved.

KITE FISHING.

This mode of fishing is much practised here, and I was able to get a specimen of the entire apparatus. The kite is made of broad leaves kept extended and flat by means of pieces of light wood. To the tail of the kite some cocoons or spider webs are attached. The kite is flown from a canoe and the end of the kite tail is kept just skimming the top of the water. The gar-fish bite

at the cocoon and are then unable to let it go. The fisherman at once backs his canoe quietly, winding up the string as he does so, until he gets the fish on board, when the kite is flown again. I have not seen this mode adopted in any other group.

CIRCULATING ADORNMENTS.

At Dobu I saw in the possession of the Rev. W. E. Bromilow some large armlets and a very valuable necklace. Similar ones are in the possession of a number of chiefs who are members of a circle, entry into which is gained by the possession of some large and valuable armlet or "baggi." These adornments then become the property of the circle and are passed on from one to another and go the round of every individual member of it. So far as I could learn there is no specified time in which the article remains in the possession of a chief. The man may perhaps wish to have a change in the coveted article of which he is the temporary possessor, and this, of course, will necessitate a change all round. Mr. Bromilow is, so far as I know, the only European who has been admitted to this circle, and he may probably give us some idea of the meaning and use of the custom which I have never before known in any of the Polynesian Groups.

BURYING CHILDREN ALIVE.

At the Mission Station, Dobu, there may be seen several bright and happy children who were rescued from this horrible death. The case of the oldest may be taken as typical of them all. His father and mother were dead, and on the mother's death, as there was no one who would take care of the baby boy she had left, they were preparing to follow out their usual custom, and the child was actually put into the grave to be buried with his dead mother when he was rescued by Mrs. Bromilow, and has since grown to be a bright, intelligent lad. In the case of a girl child, some one would probably have been found to take charge of it, as girls are a source of income when they are sought in marriage; but to the New Guinea mind boys are only a source of trouble, and no profit can be gained for the trouble of rearing other people's children.

A MOTHER'S OPINION ABOUT THE MOON.

A Kiriwina mother always lifts up her child to the first full moon after its birth. This is to make it grow fast, and that it may talk soon. I could get no reason for this singular custom, one which I have never before met with, and which is (so far as I know) a new instance of moon worship.

CHILDREN'S GAMES.

One of the most interesting sights which I saw at Dobu was a game played by a number of girls. This game must usually, I think, occupy two or three hours ; but on the particular occasion it was a good deal abbreviated for my sake, but even then it occupied a long time. The girls all sat in a circle and sang a few words very sweetly. Then one, who was the leader, pretended to strike each one with a knife in turn, and each girl said, as the pretended stroke was given, "That knife is blunt !" Then there was the pretence made of sharpening the knife, accompanied with a descriptive song. After this all the circle joined hands, finger to finger, and a song was sung as each finger was loosened. All this occupied a long time, as the song had to be sung over and over again as each finger of every girl in the circle was loosened. Then some went out who were supposed to be witches, seeking to kill one of the others; and there was a lot of singing, gesture language, and appropriate action until these witches were driven away ; in fact, there was a regular scrimmage before this was finally accomplished. After this all the girls stood closely locked together to represent a bunch of bananas. One was snatched away at a time by a witch. The owner of the "bananas" walked round, and, missing one, asked of the fool or silly person, who was supposed to watch, "Who stole my banana?" The answer was given in each case, "I don't know." This went on till all the "bananas" (girls) were taken away. Then there was a great disturbance. The witches were found, driven away, and the girls rescued. Then there was a game illustrative of a wallaby hunt, and it was very amusing to see the way some of the girls imitated the hunted wallabies, skipping and jumping away from their pursuers. All these were accompanied with descriptive songs, which, unfortunately, I did not understand.

All the islands of the d'Entrecasteaux Group have abundant evidence of volcanic action, but, as in New Britain, I found no lava streams. All the ejected matter is pumice, of which, indeed, most of the islands there consist. There are many boiling springs in the group, some of which, on Dobu and on Fergusson Island, we visited. We landed at Numanuma on the latter island, and after an hour's good walking in the hot sun we reached the fumaroles. The first intimation of their proximity was a large stream of boiling water flowing to the coast. There were many boiling springs along its banks, some of them emitting only boiling water and others boiling mud. Then, after receiving many cautions from our guides to follow them closely in single file and not to step out of the track, we went on to the Geysers. There were several of them, and the sight was very interesting. A

description of one of them may be taken as typical of all. In the rock or pumice formation there was one or more irregularly shaped pits, but how deep these were it was impossible to say, as no one could approach them near enough to see. From these pits there was just a light steam escaping, and then in a few minutes there was an explosion, accompanied by an eruption of boiling water. The water was thrown to a height of about 20 or 30 feet. After this subsided we could only hear the angry roar beneath; then perhaps a few small dashes of water would be ejected, and then more roaring and trembling of the ground which was soon followed by another violent outburst. I managed to get a few photographs which give some faint idea of the appearance of the place and of the Geysers in action. I noticed no sulphur deposits, so that, in this respect, these fumaroles differ from those in Seymour Bay, on the opposite side of the bay which I visited in 1890. The natives told us that some Normanby natives would not believe that the water was boiling, and so went to bathe in one of the pools and were scalded to death. I think it is more probable that they had incautiously ventured too near one of them and the ground had given way under them, or that they were overwhelmed by an unexpected eruption of water. They told us also that one of their own women who had quarrelled with her husband once threw herself into one of the holes in her anger and was never seen again. We experienced no earthquake during our visit, and this, the people told us, was a very unusual experience.

SIGNS OF MOURNING.

In addition to the universal sign of blacking the face or body, I noticed several other signs which, to me, were peculiar, and one which I had not previously met with in any Papuan race, though it is quite common amongst eastern Polynesian peoples. This was the custom which I saw amongst the Goodenough people at Bwaidoga, on that island, of amputating a joint or joints from the fingers of relatives when any of their friends were sick. At a village called Iakalova we saw people whose hands had been thus mutilated—one woman having one or two joints removed from her first, third, and fourth fingers; many others, including mere children, were thus disfigured. This is an interesting instance of similarity amongst those whom some people think are essentially different races. In the Engineer Group the women have blackened faces and bodies, and shoulder belts of the white Cowrie shells. At Fergusson Island the women wear white plaited armlets, a broad belt of the same kind round the body, just above the breasts, and a narrow one all of the same material crossed round the neck. On Dobu they wear a great bundle of small cords suspended round the neck.

YAM FEAST AND SPIRIT WORSHIP.

When we reached the Trobriands Group the yearly Yam feasts were being held, and every village had its yam houses filled with the new crop, and feasts and dances were being held daily. On these occasions there is a great display of native property. The principal chief is kept for days almost without food, or only fed with some particular article and some betel nut. On a stated day he comes from his retirement and after certain ceremonies he ties a piece of prepared fibre round the posts of the yam houses. This makes them "taboo," and no one can touch them. Platforms are then built and on these are displayed all kinds of valuable property, such as armlets, native money, &c. Then for many days the feasts and dances are held. When all is finished the people assemble, shout, beat the posts of the houses, overturn everything where a spirit may be hiding, and do all that they can to drive them away, and then the feasts are over. The probable explanation is that the spirits have been made wealthy for another year. They have got the spirits of the yams, and so have enough for their needs; they have got the spirits of the property, and so are made wealthy; they have heard the songs and seen the dances, and now they are not wanted to frighten or disturb those who are living, and so they are driven away. It is much the same idea as that of displaying property before a dead man and putting a yam into his hand before he is buried, which I have noted in another place.

POWER OF CHIEFS.

Unlike those in other places in New Guinea, the chiefs in the Trobriand Group possess great power—as great indeed as that exercised by eastern Polynesian chiefs in old days. When Enamakala, the great chief of Kiriwina, comes from his house no one dare walk about the village in an upright position. Everyone either walks in an abject, stooping position, or in some cases actually crawls on hands and knees, and no one speaks above a whisper when he is talking. This man has thirty-one wives, each one of whom has, by the aid of her relatives, to keep a yam-house filled with food for him. Five of his wives have died, four committed suicide, and one he killed.

KIRIWINA VILLAGES.

Much of the land in the Trobriands is comparatively open country. This is due, I think, to some extent to the bush having

been cut down for their large yam gardens. The site of a village, or an old village site may, however, always be known by a large clump of fine fruit-bearing trees, in the midst of which the village is situated. This is quite a distinctive feature of the Trobriands villages.

NEW BRITAIN.

In this group when I landed there in 1875 there was not a single white man resident there, and where the people then were wild, naked savages I saw great changes, but I am not able now to give any detailed account of them, and I must reserve this for some other occasion. I was much impressed, however, with one instance of the

FORMATION OF AN ISLAND.

On one of the points of Blanche Bay, three of the best-known mountains in New Britain are situated. These are called the "Mother and Daughters." The "Mother" is 2,000 feet high; the others are a little lower, and not so regular in shape. They are all certainly of volcanic origin, as is also the whole of the surrounding district, which is composed entirely of decomposed pumice.

In 1878, when I was resident in the group, an active volcano broke out about halfway up the side of the Mother. It was a grand and fearful sight. The column of fire, smoke, and ashes was, to all appearance at least, as high again as the Mother, thousands of tons of pumice were ejected, the sea being covered for miles, and presenting the appearance of a great, sandy desert with no water visible. The water in that large bay was boiling hot, even to the very farthest point of the bay, and the whole country was covered with ashes which killed most of the cocoanut-trees and all the gardens of the people.

The bay is very deep, and is about 8 miles wide at the place where the island of which I am writing was upheaved. I visited the place a few days after the outburst, and while the volcano was still in furious action. The natives told me that during the first days large jets of steam had been observed coming out of the bay in a direct line between the volcano and a village on the mainland called Karavia, and that a new island had been found at some little distance from that village. With some difficulty I got a crew to take me to it, and found an island nearly 3 miles in circumference and, in some parts, about 60 feet high. The island I found was situate on a spot which I remembered as being a

comparatively shallow bank of reef in the bay, but over which I had often sailed in my boat. It was quite hot, and as it was impossible for anyone to walk on it without shoes, I had to land alone. The steam was very dense, and I soon lost sight of the boat, as my crew also did of me. Often I had to stop and wait for a puff of wind before I could see whether I could step over some crevices out of which the steam was hissing. I soon found that the centre of the island was a crater of boiling water, near to which it was not safe to venture. I managed to keep a zigzag course until my course was stopped by a large stream of hot water running from the crater to the bay. I often landed on the island afterwards and noticed that the water remained hot for some years, but the crater was gradually filled up by the subsiding pumice around it. This island has been named Vulcan Island. I visited the same island a few months ago, and these are some of the changes which I noticed as having taken place during the eighteen years which have elapsed since it was upheaved from the sea. It is now only about 30 feet high, and that only at one end. This I attribute to the consolidation of the ejected matter and to the wearing away by wind and weather. These influences have also affected its circumference, as I judged that is not now more than 2 miles in circumference. A channel which formerly existed between the new island and a small rocky islet has been filled up with the material washed away from the shore of the new island. The whole island is covered with scrub, and there are Casuarina trees on it which have attained a height of 30 or 40 feet.

This account shows that the progress of disintegration and the growth of vegetation consequent thereon are very rapid in these tropical countries, and it will also show, I think, that, whilst volcanic areas are areas of subsidence, they are areas of upheaval also, and that to a much greater extent than is believed by many in the present age.

So far as my experience in New Britain is concerned, I am quite satisfied that the peculiar feature of the coral formations in that group can only be accounted for by upheaval, and not, so far as I have seen, by any process of subsidence, though I believe that this will account for many other formations in other groups in the Pacific.

No. 10.—A FEMALE HERMIT OF THE SOUTH PACIFIC.

By the late Rev. W. Wyatt Gill, B.A., LL.D.

(*Read Monday, January* 10, 1898.)

The island Atiu, in the Hervey Group, is famous for its caverns, the largest of which is called Anataketake. To enter this vast temple of Nature, it is necessary to descend about 20 feet through a chasm in the rocks, at the bottom of which are several majestic openings. Innumerable small birds breed in this cave. With the aid of flambeaux, it is possible to travel a mile underground amid its almost interminable windings. Water continually drips from the arched roof, which is from 10 to 15 feet thick, and is supported by superb columns of stalactite. From the glittering floor, which presents a wavy appearance, rise less attractive stalagmites. The fretwork ceiling sparkling in the light of torches is a sight never to be forgotten. A lake abounding in eels and shrimps occupies the centre.

The story of the discovery of the Cave Anataketake is very romantic. A woman named Inutoto, being cruelly beaten by her husband, wished effectually to hide herself away. In looking about for a place of concealment she came upon this wonderful cavern, and lived there in utter solitude for many years. She found no difficulty in sustaining life. Her now repentant husband sought for her in vain, and then mourned for her as dead. Eventually a man in chase of a bird—the woodpecker—discovered the cave, and then the hermit, who was thus restored to her husband, Paroro. Her song, composed in the cave, has been carefully handed down by tradition, I subjoin :—

SONG OF INUTOTO, THE HERMIT.

INTRODUCTION.

Patapu ei, patapu ei,	My person is sacred, very sacred.
Akariki i te matangi,	Awake some favouring breeze ;
Te naku nei i te tane !	I am sorrowing for my husband.

FIRST STANZA.

E utu matangi e,	Oh, for a steady breeze,
E mavake te kau,	Directed by the gods !
Kua akaipoi ra i te vaine	Great is the misery of her
Aru marama ki te tane !	Who counts her widowed moons !
Rai oti ei,	In all thy might
Akariki i te matangi,	Awake thou favouring wind ;
Akariki i te matangi,	Yes ; awake thou favouring wind ;
Ki te marangai tai,	Some easterly breeze ;
Kia ana mai ake a Paroro e,	So that Paroro may come
Ei rave ake i tona vaine,	And be re-united to the wife
Te naku nei ki te tane ra.	Who is sorrowing for her husband.

SECOND STANZA.

E utu matangi e,	Oh, for a steady breeze,
E mavake te kau,	Directed by the gods !
Kua akaipoi ra i te vaine	Great is the misery of her
Aru marama ki te tane !	Who counts her widowed moons !
Rai no te ariki,	May my chief* be famous !
E ngarue te au no te ariki,	May his rule be prosperous !
Ngarue te au. E tu	Aye ; may he prosper.
Ki te tai vera oki o Kaukura,	Stand thou on ocean's burning strand,
I te upoko o Inutoto,	Thou lord of Inutoto,—
Te vaine pare ariki,	Of her who once was crowned,
Te naku nei ki te tane !	But is now sorrowing for her husband.

No. 11.—CONCERNING THE NAME "UNGA" FOR "SLAVE" AT RAROTONGA, SOUTH PACIFIC.

By the late Rev. W. Wyatt Gill, B.A., LL.D.

(*Read Monday, January* 10, 1898.)

The indigenous arrowroot plant [*Tacca pinnatifida*] of the south Pacific has one or two large tuberous roots, surrounded by many smaller ones. To the highly-imaginative native† mind the large tubers symbolize the chief or chiefs ; the smaller ones the landed proprietors owning allegiance to, and by blood related to, the chief or chiefs. But besides these, there are a great number of *tiny tubers*, called "unga," *representing the serfs*, or "little people" "tangata rikiriki," as they are often called—*i.e.*, people of no account whatever !

The correctness of this interpretation is evidenced by the Rarotongan phrase for "dust" "ungaungā—one," literally "grains of earth." Again, in the Rarotongan Bible [Matt. xv, 29, and Mark vii. 28] for "crumbs" we have "ungaungā kai," literally "grains of food." In these phrases the plural is made by repeating the noun "unga"—"grain." The underlying idea is, that the slave "unga" is but an insignificant grain or unit that in the nature of things can never rise to anything great. And such is

* Her husband Paroro was a renowned chief. The crown referred to in this stanza was made of parrakeet feathers. Paroro is imagined to be on a visit to Mitiaro or Mauke, lying to the east of Atiu. Strangely enough, there is no reference to the surroundings of the hermit. It is impossible to fix a date for this song ; in my own judgment it was, as the natives of Atiu assert, composed many generations ago.

† This explanation was many years ago authoritatively given me by Maretu, the clever and much-respected pastor of Ngatangiia, Rarotonga. He observed that the simile equally applies to the "Teve" plant, *Amorphophallus campanulatus*, of the islands. The "chats" "karoi," of the Teve-plant represent the serfs, "unga."

really the teaching and condemnation of heathenism—compelling the many to be slaves for ever; whilst the favoured few are to enjoy all good things. And this by a supposed Divine appointment! In India this notion has, through the astute intellect of their sages, developed into the iron system of caste.

In the Pacific, as elsewhere, *sometimes* the offspring of a slave woman married to a high chief inherits the father's titles and power.

The word "unga" in Rarotongan also signifies "hermit-crab." Some of the younger natives imagine when using the word "unga" in the sense of "slave," that there is a sly allusion to the well-known habits of the hermit-crab—the slave living in a home belonging to another! But the elder natives were too accurate observers to overlook the important circumstance that the hermit-crab appropriates the *forsaken* shell of another, whereas the slave enjoys the protection of the land-owner or chief, to whom he owns allegiance and service. I regard this explanation as extremely modern, although very ingenious.

No. 12.—TAHITIAN AND HAWAIIAN TATTOOING.

By Miss Teuira Henry.

(*Read Monday, January* 10, 1898.)

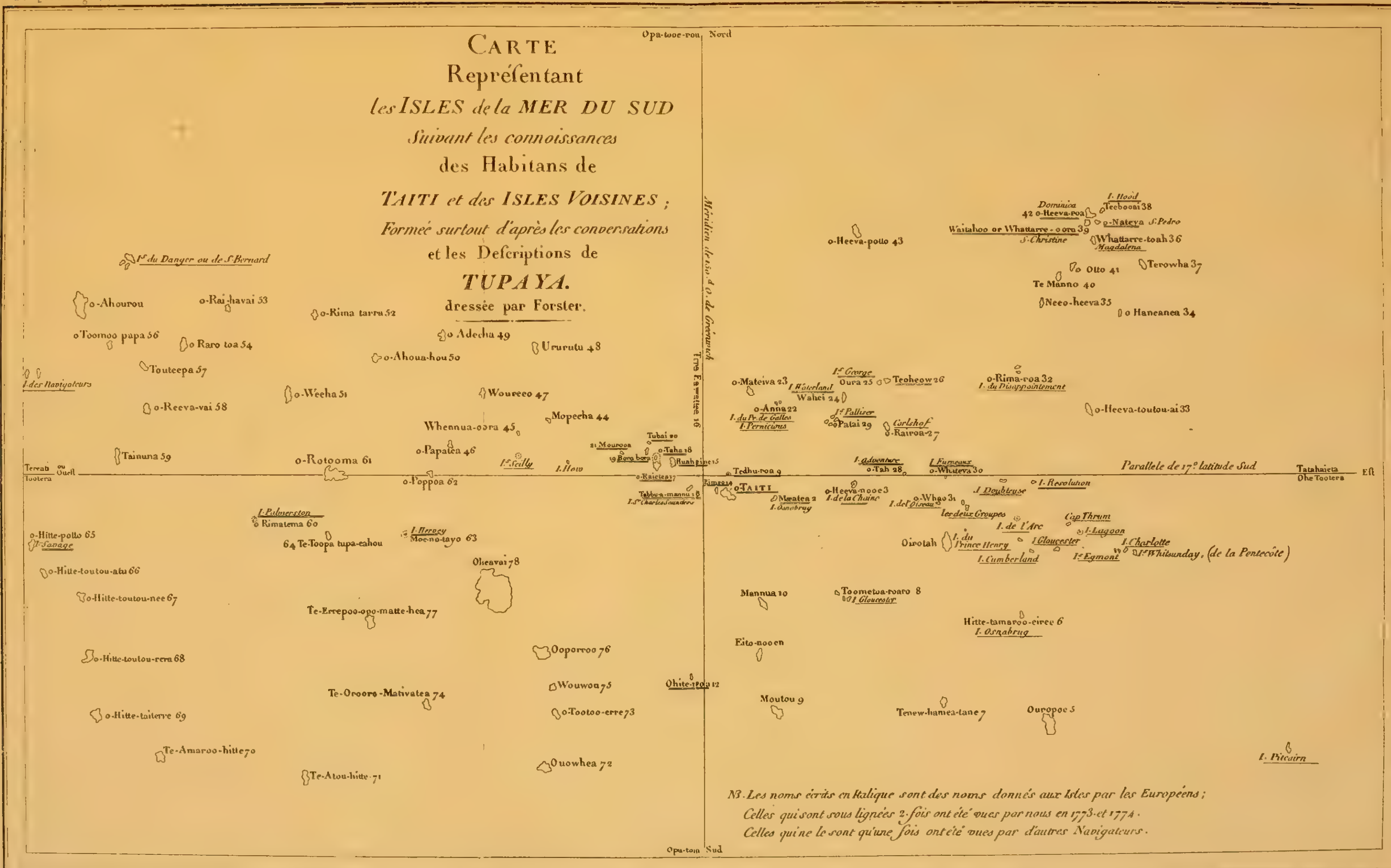
No 13.—BLACK, RED, AND WHITE, AS SYMBOLS.

By John Fraser, B.A., LL.D.

(*Read Monday, January* 10, 1898.)

To Illustrate Paper by S. Percy Smith.

De Quatrefages, les Polynesiens



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No. 14.—NOTES ON THE GEOGRAPHICAL KNOWLEDGE OF THE POLYNESIANS.

By S. Percy Smith, F.R.G.S., Surveyor-General, Wellington, New Zealand.

(*Read Monday, January* 10, 1898.)

Part II.

In a paper read before Section E of this Association in 1894, I endeavoured to show that before the advent of white men into the Pacific, the Polynesians were well acquainted with the geography of the Southern Ocean. In support of this I quoted some forty names known to the Maoris of New Zealand and retained in their traditions and chants, most of which can be identified with islands of Central Polynesia.

A good deal of light has been shed on this subject since the publication of that paper, principally through contributions to the "Journal of the Polynesian Society," all of which go to prove the general accuracy of the identifications given in the paper quoted, whilst at the same time this later information adds many names of lands known to the inhabitants of other islands outside New Zealand.

There is very little in the paper quoted above that required alteration, due to the acquisition of this later knowledge; but one statement therein should be amended. In deducing the few dates given in that paper, only twenty years was allowed as the length of a generation. The consensus of opinion of several Polynesian scholars, shows that twenty-five years is more probably nearer the truth, and this number will be used in this paper wherever it is necessary to compute dates.

The following notes, whilst dealing with the general geographical knowledge of the Polynesian, will take Tahiti as a standpoint, and from the information gathered there, it will be shown how their traditions confirm those of New Zealand, and at the same time prove the extent of the great ocean known to them.

It is probable that the last communication the Maoris had with Tahiti and the Central Pacific took place at the time of the great *heke* or migration to New Zealand—which we may fix, from the

mean of a very large number of genealogies, at about the year 1350, or twenty generations back from 1850. Tradition says that one or more canoes have left New Zealand since that time for Hawaiki, but no certain news has ever been heard of the crews since their departure. Whether they reached any of the islands or not, is uncertain ; but none ever came back. We may except from this statement the voyage of the canoe Totara-i-keria, which left New Zealand only a few years after the arrival of the fleet in 1350, for she did return, and was followed back from Hawaiki —which probably means here the Central Pacific—by a fleet, which was wrecked on Motiti Island, Bay of Plenty, New Zealând, during a severe storm. None of the canoes of this fleet ever returned to Hawaiki, if we may believe Maori traditions.

If it is true that the Maoris were formerly in the habit of making voyages between New Zealand and the Central Pacific, it is to be expected that some record of those voyages would be found in the traditions of Tahiti, or some of the adjacent islands. On this point, I have been on the look-out for many years past, but through lack of information as to the Tahitian traditions, had made no progress—indeed, had almost given up the hope of ever securing any information on the subject—when accident put in my way a very extraordinary confirmation of the Maori traditions. It will be known to many members of this section, that one of the early missionaries to the Society Islands was the Rev. J. M. Orsmond, who arrived in Tahiti in 1817. Mr. Orsmond appears to have been one of those gentlemen to whom Polynesian scholars owe a great debt of gratitude, in that, instead of despising the native traditions, he collected a great many, and carefully preserved them. These are now in the possession of his grand-daughter, Miss Teuira Henry, who is preparing them for publication. In the course of a correspondence with that lady, I asked her if she could find amongst Mr. Orsmond's papers, any reference to other lands outside the Tahitian group, and mentioned the name Aotea-roa as that of New Zealand, asking her to specially look for this name. This brought a response which was a delight to me, after the years I had been searching for such information ; but it was not until further inquiry, and even after a careful tracing taken from Mr. Orsmond's original document had been received, that the information was accepted as quite genuine. It has already been stated in the former part of this paper that Aotea-roa, is the Maori name of New Zealand ; the discovery, therefore, of this name in the following ancient Tahitian chant, is the direct proof of the argument that the Maoris and Tahitians were mutually acquainted with their respective homes. By Miss Henry's kind permission I am able to give the Tahitian chant in the original, together with her translation.

THE TAHITIAN CIRCUIT OF NAVIGATION.

O Havaii te tumu. Mai Havaii atu te taata i te mau fenua atoa; ua tae i na hiti e ati roa a'e.	Havaii was the origin. From thence people spread forth to all lands; and they arrived at the encompassing borders.
I tae na Hitia, i te Tuamotu e i Maareva.	They went east to the Paumotu (isles) and to Mangareva.
I tae na To'a, na Tupua'i; na Rurutu na Fenua-ura; na Rimatara; na Rimatara e na te Aotea-roa o te Maori.	They went south to Tupua'i; to Fenua-ura to Rurutu; to Rimatara; to Rimatara and to the Aotea-roa of the Maori.
I tae na Too'a, na Manitia; na Raroto'a; na Atiu; na Ahuahu; na Aitutati; na Vavau. I tae na Hamoa na Tutu-ira, Uporu, e na Tavai'i; i tae roa na reira.	They went to the west to Manitia, to Rarotonga; to Atiu; to Ahuahu; to Aitutaki; to Vavau (of the Friendly Isles); and on to Samoa; to Tutuila, to Upolu, and to Savai'i; they arrived in all that direction.
I tae na Toerau, na Ma'atea, na Nu'uhiva-roa, e i Aihi ahuahu.	They went north to Makatea, to distant Nu'uhiva (Marquesas), and to burning Aihi (Hawaii).

ADOPTION OF NAMES.

Te fenua e tona i'oa e rave mai; te fenua nei e te i'oa i topa'tu.	The lands took different names these lands adopted names.
O Tahaa ra, o Uporu ia: o Haapape o Uporu i Tahiti; o Poraporara, o Vavau ia; o Pape-noo o Vavau i Tahiti; o Hiva tei uta i Tahiti, o Raiatea e tei pihai rii atu o Hamoa.	Tahaa was called Uporu; and Point Venus was Uporu in Tahiti; Porapora was called Vavau, and Pape-noo was Vavau in Tahiti; there was Hiva inland in Tahiti, and there was Hiva in Raiatea, and close by it is Hamoa.

With reference to the above chant, Havaii is the ancient name of Raiatea, and as I have shown, the same as that particular, Hawaiki whence I believe some of the Maoris came to New Zealand. Tuamotu is the former name of the Pau-motu group. Maareva is Mangareva or Gambier Island. Tupuai and Rurutu are still known by those names; they lie to the E.S.E. of Rarotonga, and form part of the Austral group. Fenua-ura is the ancient name of Manuae in the Hervey Islands. Manitia is intended for Mangaia, the other ancient name of that island being Ahuahu. Atiu, Rarotonga, and Ai-tutaki are well-known islands in the Cook group. In the latter name will be noticed the Tahitian objection to the letter "k," which they render in the chant by "t". Aihi is Waihi, an ancient Tahitian name for the Sandwich Islands, as is shown in the following quotation from

another Tahitian chant published in Vol. III, p. 138, of the "Journal of the Polynesian Society":—

Oia o Aihi, fenua o te matau nui, fenua e a noa mai te vera hiehie, fenua hutiahia mai na te matapoopoo o ravea mai te Tumu mai! Oatu Oahu ia.	That is Aihi, land of the great fish hook, land where the raging fire ever kindles, land drawn up through the undulations of the towering waves from the foundation. Beyond is Oahu.

This name Waihi, or Owaihi, is also known to the Maoris as that of some land beyond Hawaiki, or Tawhiti-nui, which latter is the Maori name for Tahiti. It is found in the ancient chant used in dragging the Tainui canoe out of the forest before she started for New Zealand with the fleet. "*Ki tua o Rehia, ki tua, o Waihi*" (beyond Rehia, beyond Waihi).

The most important name in the chant, however, is "Aotea-roa o te Maori" ("Aotea-roa of the Maori"), where we have the name of New Zealand coupled with that of the Maori. The fact of this mention of the Maori was so much to the point—the expression was so pat—that it raised doubts as to whether this was not a modern innovation. But a little reflection will show that it is quite natural. Although now used as a racial name, the original meaning of Maori is "native," or the ordinary Polynesian mankind as distinguished from gods or white people. Miss Henry tells me it is the ancient Tahitian word for "native," but has long since been replaced by "*maohi*."

I account for the introduction of Maori into the native Tahitian chant as follows:—In ancient days, before the arrival of the fleet in New Zealand in 1350, several voyages between there and the Central Pacific had been made. We may imagine what would take place on the arrival of one of these expeditions at Aotea-roa after a long interval probably. On meeting the aboriginal inhabitants the voyagers would ask, "Who are you?" The answer would be, "*He tangata maori matou.*" "We are natives"—not strangers or gods as the voyagers would appear to the aborigines.* Hence on the return of the voyagers, in giving an account of their travels—which, like all Polynesians, they would do even to the minutest particulars—they would say the people of Aotea-roa were "*Tangata Maori*" or Maoris; and hence to the Tahitians New Zealand would come to be called "Aotea-roa o te Maori," as in the chant.

This would seem to show a knowledge of New Zealand by the Tahitians in former days. In the following Tahitian chant, also given me by Miss Henry, is mentioned another name—a very

* That such questions were asked by the Polynesians on their arrival at a new country, see "Journal, Polynesian Society," vol. v, p. 27, describing the arrival of the Morioris at the Chatham Islands.

ancient one—formerly applied to New Zealand, but there is some uncertainty as to whether this particular Nu'uroa (in Maori, Nukuroa) is intended for New Zealand. The fact of its being the home of Tangaroa is rather against it; for although Tangaroa was one of the great primary gods of New Zealand, he never occupied the supreme place of god and creator, as he did in Samoa, Tahiti, and Hawaii. With the Maoris, Tangaroa is the god of the sea—Neptune, in fact—presiding over all voyagers, fishing, or matters relating to the sea. Fornander has shown that the supremacy of Tangaroa in Hawaii is due to that god's particular cult having been introduced into the group during the period between twenty-four and thirty generations ago, when Hawaii received from Samoa and Tahiti large numbers of immigrants who finally became predominant, and then succeeded in ousting from the supreme position the original god Tane, who was also the principal god of the Maoris, but who, as war became more and more prevalent in New Zealand, was in a great measure superseded by Tu—"Scarlet belted Tu"—the god of war.

In the first part of this paper, it was shown that Nukuroa, besides being an ancient name for New Zealand, was also that of some country known traditionally to the Maoris, probably some land far to the west—perhaps the continent of Asia. The name means "long land," "extensive land," or "distant land." It is possible that the following Tahitian chant refers to this ancient Nukuroa, and not to New Zealand, or the little island of Mitiaro of the Cook group, the old name of which was also Nukuroa.

THE GODS AND THEIR ORIGINS.

Tupu te atua, tupu te fenua;	Gods grew, and lands grew;
E tupura 'a fenua, e fanaura 'a atua.	There was growth of lands, and birth of gods.
O Ta'aroa te atua, o Nu'uroa te fenua.	Ta'aroa was the god, Nu'uroa was the land.
O Tu te atua, o Tai-nuna te fenua.	Tu was the god, Tai-nuna Island was the land.
O Tane te atua, o Rai-hamama te fenua.	Tane was the god, Ra'i-hamama (or Rairoa) was the land.
O Hau te atua, o Papa-tea te fenua.	Hau was the god, Papatea (Maatea, or Makatea) was the land.
O Oro te atua, o Opoa i Havaii te fenua.	Oro was the god, Opoa in Havaii was the land.
O Hiro te atua, o Uporu te fenua.	Hiro was the god, Uporu was the land.

We have in the above enumeration of gods the great quartette who, according to Maori and other traditions, were the great gods of Polynesians--Tane, Tu, Tangaroa, and Rongo. Hau is probably the Maori Haumia, the god of the fern-root—the staple article of food of the Maori. Hiro, I think, can be proved to be a more modern god, besides being the name of a celebrated navigator who flourished about twenty-four generations ago, and is well known to Maori, Tahitian, and Rarotongan traditions.* Of the lands named as the dwelling-place of these gods (or possibly those in which their worship predominated), Tainuna (translated by Miss Henry as "Mixed-up shoal") is one of the islands formerly existing north of the Paumotu Group ; Rai'hamama (to be referred to later on, and which Miss Henry translates into "Open sky") is an island to the east of Tahiti, shown on Tupaea's chart, as is also Papatea in the same direction, and which is also mentioned in the Samoan traditions. Uporu, the last name on the list, is the old name of Tahaa of the Society Group.

In part No. 1 of this paper it was stated that Turi, the captain of the Aotea canoe which arrived in New Zealand about 1350, together with other canoes forming the fleet, was known by name to the traditions of the Tahitians. I am again indebted to Miss Henry for the following few particulars regarding him, which are introduced here as corroborating the statement formerly made as derived from the New Zealand traditions. "Turi was a hero of former times, born of the gods in Raiatea ; and after many conflicts with them, finding his domestic affairs unsatisfactory, he left Raiatea and went to Tahiti ; but at last he left the Tahitian Group altogether and was never heard of afterwards. So it came to be believed he never died, but was a god in other lands. Turi's first wife was Raurea (in Maori, Raurenga), meaning "Turmeric leaf," and he left her in Raiatea, but took another from Te Aharoa, in Tahiti, away with him ; she was named Te Puta-ia-fiu (in Maori, probably, Te Puta-ia-whiu)."

Although brief, the above tradition fully confirms the Maori traditions concerning Turi, in which it is stated that he left his home at Rangi-atea (which is the Maori form of Ra'iatea) in consequence of troubles arising between himself and the *ariki*, or great priest Uenuku, who was a very powerful chief in those times. The name of Turi's wife who came across the seas with him does not agree with the Tahitian name ; with the Maoris it is Rongorongo, and it was from her brother Toto, that the Aotea canoe was obtained in which the migrants crossed over to New Zealand. Rongorongo's father was named Rua-nui-a-Pahiwa, and

* See "Journal of the Polynesian Society," vol. II, p. 30, *et seq.*, vol. IV, p. 104, *et seq.*, where several of his voyages are mentioned,

it is possible that the Maori name of Tahiti—Tawhiti-nui-a-Rua*—is derived from him. In the traditions concerning Turi, as preserved by the Maoris, we find that his daughter Tane-roroa married Uengapuanake, a son of Uenga-ariki, and it is just possible that this latter individual is the Uenga whose other name was Tangiia, and who lived at Hiva in Raiatea.† There is a difference in the length of the genealogies as derived from the New Zealand, Rarotongan, and Tahitian traditions of about three generations, however; so this point must be left in abeyance until further information is to hand. The history of Turi, as related briefly above, seems to show the reliability of Polynesian traditions as handed down through more than twenty generations, and proves the knowledge both peoples had of common ancestors.

In the following brief summary of some of the traditions obtained by Mr. Elsden Best from the natives of the Bay of Plenty, New Zealand, may be found, I think, another corroboration of the Maori knowledge of Tahiti in the fourteenth century. Some years—how many we know not—prior to the starting of the fleet for New Zealand, there arrived at Whakatane, in the Bay of Plenty, a canoe from Hawaiki, which was wrecked on the coast. At this time there resided in Kapu-te-rangi *pa*, just inside the Whakatane River, some people who were descendants of Toi, the great ancestor of the aboriginal tribes of New Zealand. The chief of the *pa* at that time was Tama-ki-hikurangi, who was seventh in descent from Toi. Early one morning Tama's daughter went down to the beach to bathe, where she found two men miserably cold and wet, who were the only survivors of the wrecked canoe. These men were taken up to the *pa* and hospitably entertained by the people of the place, and in return for this kindness they gave to the aborigines some preserved *kumaras—kao* (sweet potatoes), which they had preserved in their belts. This new food so pleased the aborigines that an expedition was decided on, to proceed to Hawaiki to procure some of the seed of this valuable root. The chief himself—Tama-ki-hikurangi—led the expedition; whilst Hoake, one of the shipwrecked men, went as pilot. The canoe was named "Te-Ara-tawhao." They safely reached their destination, and were welcomed by a chief of the land named Marutai-rangaranga, whose song of welcome has been preserved. It was some time after their arrival that a number of the people of

* The island of Oahu, in the Hawaiian Archipelago, has also this suffix of "Rua," but in this case the Rua (or Lua), from whom the name is derived, is much more ancient, as will be seen from the following quotation from "Na mele ai Moku," a collection of Hawaiian Chants, p. 123:—"Hi mai o Papa mail oko mai o Kahiki-ku, ku inaina lili i ka punalna, hae manawa ino i ke kane o Wakea, moe ia Lua he kane hou ia, hanau o Oahu-a-Lua."

† See "Journal of the Polynesian Society," vol. iv, p. 122, *et seq.* In this paper the Rev. J. B. Stair has recorded several voyages between Samoa, Tahiti, Rarotonga, and other Groups, proving conclusively the extent of the geographical knowledge of the Polynesians in the thirteenth and fourteenth centuries.

Hawaiki decided to migrate to New Zealand in consequence of troubles that had arisen through land disputes and other causes. Then was the fleet of canoes built, which, as has been shown, arrived in New Zealand about the year 1350. One of these canoes was the "Mata-atua," and, luckily, most of the sacred *karakias* or prayers connected with her building and launching have been preserved. In the *tau* or chorus used in hauling the canoe out from the forest occur the following lines :—

> Kapua hokaia i runga o Tahiti-nui-a-Te-Tua,
> Ka tatau ana ki runga o Kapu-te-rangi,
> Puke i Aotea, ko Toi te tangata o te motu.
>
> Clouds that stride above on Great Tahiti of Te Tua
> Will rest on top of Kapu-te-rangi,
> The hill at Aotea, where Toi is chief of the island.

The above *tau* names Tahiti as the land of Te Tua, evidently some great chief, and it shows also at that time a knowledge of Aotea or Aotea-roa, of which Toi is said to be the chief, meaning no doubt his descendants. Miss Henry says that Tua is the name of a very ancient high chieftain family in Tahiti, which seems again to prove the Maori knowledge of that island, and to show where the Mata-atua canoe was built. The tradition goes on to say that the people who received Tama-ki-hikurangi in Tahiti were the Tini-o-Te-Oropoa, and that the Mata-atua sailed from Paea. Both Oropoa, or Oropaa, and Paea are districts in Tahiti, but we must be on our guard here, for these names may have been learnt in later days from Tahitians visiting New Zealand in whale ships, and moreover, I think the Tini-o-Te-Oropaa people can be shown to be known to Maori tradition; but the name was not derived from the district referred to. It would take me too far away from the matter in hand to explain this. It is different with names embalmed in the *karakias*; they may be taken as correct, for it would have been sacrilege to have altered them.

In reference to the name Maru-tai-rangaranga mentioned above, it is just possible that this is the same man referred to in the Rev. J. B. Stair's "Samoan Voyages,"* as the father of Uenga. The genealogies preserved by both the New Zealanders and Rarotongans show the age at which he flourished to be very nearly the same—quite near enough to allow of both the traditions referring to the same person.

The evidence which has now been adduced shows pretty clearly that both Maoris and Tahitians were mutually acquainted with their respective countries in the thirteenth and fourteenth centuries, if not long before, and that communication was not

* Journal of the Polynesian Society, vol. IV, pp. 103, 130.

infrequent in those days. Moreover, it also supports the theory enunciated in the first part of this paper, to the effect that the immediate Hawaiki from which the Maoris came to New Zealand, was Havaii, the ancient name of Raiatea of the Society Group.

That the Tahitians had an extensive knowledge of the Central Pacific and far beyond it, has been demonstrated to a certain extent above; but we now come to consider more positive evidence as illustrated by the information given to Captain Cook and Sir Joseph Banks, by Tupaea, who accompanied them on the latter part of the "Endeavour's" voyage from Tahiti to Batavia, where Tupaea died, 11th November, 1770. The chart drawn under the direction of this learned Tahitian by the officers of the "Endeavour" has been fully commented on by Forster, Hales, and De Quatrefages;* but many of the islands shown in this chart, and in the list published by Forster, were not identified by any of those authors. It is for that reason that the list is reproduced below, with the identifications I have been able to arrive at. I feel it the more incumbent on me to do so because Admiral Wharton, Hydrographer Royal, the editor of "Cook's Journal," has hazarded the remark that few of these islands are capable of identification, by which the learned Hydrographer has unintentionally cast a slur on the *bonâ fides* of the Tahitian priest and navigator under whose direction the chart was drawn up.

Forster says (loc. cit., p. 511) "Tupaya (Tupaea in modern Tahitian) the most intelligent man that ever was met by any European navigator in these isles, had himself been ten or twelve days' sail to the westward of O-Raiedea (Raiatea), which, according to Capt. Cook's computation, would make 400 leagues, or about 20 degrees of longitude. This man when on board the "Endeavour," gave an account of his navigations, and mentioned the names of more than eighty isles of which he knew, together with their size and situation, the greater part of which he had visited; and having soon perceived the meaning and use of charts, he gave directions for making one according to his account, and always pointed out the part of the heavens where each isle was situated, mentioning at the same time that it was either larger or smaller than Taheitee (Tahiti), and likewise whether it was high or low, whether it was peopled or not, adding now and then some curious accounts relative to some of them. . . This chart I have caused to be engraved as a monument to the ingenuity and geographical knowledge of the people of the Society Isles, and of Tupaya in particular."

In studying this chart there are some things which must constantly be borne in mind. First, that neither Cook, nor Banks,

* Forster's "Observations," London, 1778. "Ethnology and Philology of the United States Exploring Expedition," 1846. "Les Polynésiens," by A. De Quaterfages, Paris, 1864.

nor any of the officers of the "Endeavour" had good ears for catching native sounds, a failing which seems to attach to the English much more so than to the French. For instance, in the New Zealand names preserved by Cook, many are very unlike the reality, whilst those written by D'Urville are nearly all easily recognised, and many of them are exact. Second, those who took down the information supplied by Tupaea understood but little of his language, and, therefore, in some cases, descriptions have become part of the proper names on the chart. Third, the error already pointed out by Hale and De Quatrefages, that through this ignorance, some parts of the chart have been inverted. Where the islands were unknown to Cook and his officers, their positions relatively to Tahiti are generally indicated truly; but it is tolerably clear, that during part of the operation, the chart has been turned end for end, without the knowledge of Tupaea, or without his understanding what was done, and consequently whole groups of islands have been placed in the wrong quadrant of the map, whilst retaining generally their proper mutual positions. It is quite clear that something of this kind has occurred, and Tupaea has probably helped to make the confusion worse by trusting to the supposed superior knowledge of the Europeans. We find, for instance, the words, *He too te ra* written on the east end of parallel of 17° south latitude, and *Too-te-ra* also at the west end. Now the meaning of this is "The sun set," or the west; and had there not been some shifting of the chart during the time the information was being recorded, Tupaea would never have made such a mistake as that. This is unfortunate, as it renders the identification of the islands more dependent on Cook's barbarous names than on their positions; and moreover, I think it is due to this cause that the names appear to jump from one group to another in the list below.

In the copy of the original names given below, in most cases, the "O," or article used before proper names has been given by Forster as part of the name, but in the third column, where an endeavour has been made to render the names into modern Polynesian, this is omitted. I have added to the list of identifications about thirty-four names, and shown that others are probable; these are in addition to those which Forster had already recognised. If we were better acquainted with the native names of the islands, others referred to on Tupaea's chart would be recognised. Some of those he has given are probably old names which have since been changed, thus rendering their identification a work of difficulty, and moreover, these old Tahitian voyagers probably gave names to islands which are not known to the people of those islands; as, for instance, in cases where the Tahitian alphabet did not contain letters used by other branches of the race.

Forster's List, accompanying Tupaea's Chart.

Forster's No.	Forster's Name.	The Same in Modern Polynesian.	Identified with—	Approximate. Lat. S.	Approximate. Long. W.	Remarks.
				° ′	° ′	
1	O-Taheitee	Tahiti	Tahiti	17 35	149 30	
2	Mœatea	Maitea	Maitea	17 53	148 3	
3	O-heeva-nooe	Hiva-nui	....	....	....	An island of this name is known traditionally to the Maoris.
4	Oirotah	Waerota	Waerota	....	....	Forster says, "An island larger than Tahiti; inhabited." This island, though its position is not known, is recorded in New Zealand and Rarotongan traditions, and from them its position can be determined as in the N.W. Pacific, probably near the Solomons. See "Journal "Polynesian Society, Vol. V, p. 8 (Supplement)." Tupaea's chart shows it as S.E. from Tahiti, a mistake due to the change in position of the chart already pointed out.
5	Ouropoe	Urupoi	Kurupongi	....	....	Forster says "Also larger than Tahiti, and inhabited." Shown on the chart far to the S.E.; it should be N.W. of Tahiti. The Tahitians do not pronounce the "k" or the "ng," hence this island may be identified with Kurupongi; known by tradition to the Rarotongans, and shown by them to the N.W. of Tahiti, and in the same part of the ocean as Waerota.—"J.P.S.," Vol. I, p. 25.
6	O-Hitte-tamaro-eiree	Hiti-te-maru-arii	....	....	....	Shown on chart to the S.E. of Tahiti, but is probably subject to the same error as Nos. 4 and 5, and therefore should be N.W. Possibly one of the Fiji Group.
7	Te-newhammea-tane	Te Niu-faamea-a-Tane, or perhaps Niua-mea-a-tane.	....	...	....	Shown S.S.E. from Tahiti, to the west of Ourupoe, and may be Niue or Savage Island (the "e" in Niue changes often to "a," as in Niuafou).
8	Toometo-roaro	Tumu-te-aroaro	Tumu-te-varovaro	21 13	159 45	This is the ancient name of Rarotonga.
9	Moutou	Motu	....	....	....	Forster says, "Is larger than Tahiti, and the southernmost isle Tupaea had seen, though his father had told him there were islands to the south of it. The chart shows it to be about the position of Rapa, or Oparo.

Forster's List, accompanying Tupaea's Chart—*continued.*

Forster's No.	Forster's Name.	The Same in Modern Polynesian.	Identified with—	Approximate. Lat. S.	Approximate. Long. W.	Remarks.
				′ ′	° ′	
10	Mannua	Manu'a	Manu'a	14 20	169 30	One of the most eastern of the Samoa Group, an island celebrated in Polynesian traditions as one of the earliest to be peopled.
11	Eito-nooe	Aitu-nui	....	....	....	
12	O-Hitte-roa	Hiti-roa	....	....	....	From position on chart this may be Hititoa, an ancient name of Rurutu.
13	Tabbu-a-mannoo	Tapuae-manu	Tapuae-manu	17 35	150 35	Sir Charles Saunders' Island, near the Society Group.
14	Eimeo	Aimeo	Aimeo, or Moorea	17 30	149 50	Near Tahiti.
15	Huaheine	Huahine	Huahine	16 42	151 5	do
17	O-Raietea	Raiatea	Raiatea	16 50	151 20	do
18	O-Taha	Tahaa	Tahaa	16 32	151 20	do
19	Borabora	Porapora	Porapora	16 23	151 45	do
20	Toopai	Tupai	Tupai	16 10	151 48	do
21	Mouroa	Maurua	Maurua	16 22	152 10	Now called Maupiti, the word *rua* in Tahiti having become obsolete, and replaced by *piti.*
22	O-Anna	Anaa	Anaa	17 27	145 30	One of the Pau-motu Group.
23	O-Mateiva or Matea	Mateiva	Matahiva	14 56	148 40	do do
24	O-Wahei	Wahe	Oahe	14 30	146 10	do do
25, 26	Oura and Teoheow, or Teokea.	Ura and Tiohau, or Tiokea.	Tikahau	15 0	148 10	do do
27	O-Rai-roa	Rai roa	Rai roa	15 09	147 40	do do
28	O-Tah	Taha	Tahanea (?)	16 53	144 46	do do
29	O-Patai	Patai	Apataki	15 24	146 16	do do
32	O-Rima-roa	Rima-roa	....	....	....	The chart shows this to be one of the N.E. Paumotus.
30	O-Whareva	Whareva, or Faareva	Fakarava	16 18	145 32	One of the Paumotu Group.
31	O-Whao	Fao	Hao	18 14	140 52	do do
33	O-Heeva-toutou ai	Hiva-tutu-ai	....	....	....	
34	Haneanea	Haneanea	....	....	....	
35	Neeo-heeva	Nu'u-hiva	Nuku-hiva	8 50	140 10	One of the Marquesas.
36	Whatterre-toa	....	....	....	....	
37	Te Rowha	Te Rua	Rua-uka, or Rua-pou.	9 25	140 5	do do

Forster's List, accompanying Tupaea's Chart—*continued.*

Forster's No.	Forster's Name.	The Same in Modern Polynesian.	Identified with—	Approximate.		Remarks.
				Lat. S.	Long. W.	
				° ′	° ′	
38	Teebooai	Tipuai	Tupuai	23 22	149 37	Of the Austral Group. The "i" and "u" constantly change in Polynesian. Shown on chart to be in the Marquesas, and in the voyage of the "Duff" one of that group is so called.
39	Whaterre-oora	......	......	....	....	
40	Te Manno	Te Manu	Whenua-manu	....	....	Possibly this is Whenua-manu, the ancient name for Atiu, Cook Islands.
41	O-Otto	Atu	Fatu-hiva	10 28	138 40	One of the Marquesas.
42	O-Heeva-roa	Hiva-roa	Hiva-oa	9 43	138 55	One of the Marquesas. The Marquesas drop the "r."
43	O-Heeva-potto	Hiva-poto	......	....	....	Probably near Hiva-oa.
44	Mopeeha, or Motu-hea	Mopiha	Maupihaa	16 45	154 5	West of the Society Group, Howe Island.
45	Whennua-oora	Whenua-ura	Whena-kura	16 25	154 50	West of the Society group, Scilly Islands.
46	O-Papatea	Papatea	......	....	....	Appears from the chart to be somewhere in the neighbourhood of Suwarrow Island. It is mentioned in the Samoan traditions.
47	Waureo	......	......	....	....	From the position with respect to Whenuakura this is probably Bellingshausen Island, the native name of which is Papiti. (J.P.S., III, 136).
48	Ururutu	Rurutu	Rurutu	23 30	151 25	One of the Austral Isles.
49	O-Adeeha	Atiha	Atiu	20 0	158 10	One of the Cook Islands.
50	O-Ahoua-hou	Ahuahu	A'ua'u	21 55	158 0	Or Mangaia, the ancient name of which is A'ua'u. The Cook Islanders do not pronounce the "h."
51	O-Weeha	Uiha	Uiha (?)	....	....	Possibly the isle of that name in the Hapai group.
52	O-Rima-tarra	Rima-tara	Rima-tara	22 40	152 45	One of the Austral group.
53	O-Rai-havai	Rai-havai	Rai-va-vai	23 55	147 50	" " " "
54	O-Raro-toa	Raro-toa	Raro-tonga	21 20	159 45	One of the Cook group.
55	O-Ahourou	Ahuru	Ha furu-fou (?)	19 30	174 15	Tonga group.
56	Toomoo-papa	Tumu-papa	......	....	....	
57	Touteepa	......	......	....	....	
58	O-Reeva-rai	......	......	....	....	This island is shown on the chart as to the west of Uea or Wallis Island, and the statement is made that fine hatchets come to Raiatea from there.
59	Tainuna	Tai-nuna	Tai-nuna	....	....	In J.P.S., vol. III, 136, this is shown to be somewhere between Tahiti and the Sandwich Islands.

Forster's List, accompanying Tupaea's Chart—*continued.*

Forster's No.	Forster's Name.	The Same in Modern Polynesian.	Identified with—	Approximate. Lat. S.	Approximate. Long. W.	Remarks.
				° ′	° ′	
60	Rima-tema	....	....	....	....	Tema is the name of an island near Danger and Nassau Islands.
61	O-Rotooma	Rotuma	Rotuma	12 30	177 E.	North of the Fijian group.
62	O-Poppoa	Papua	Pupua	14 50	138 55	Houden, or Disappointment Island, named also Pukapuka, but from position on chart it is probably north-west of Samoa, and may be another name of Futuna or Horne Island.
63	Moe-no-tayo	....	....	....	....	
64	Te Toopa-tupaeahou	Tupatupa-hau	....	....	....	
65	O-Hitte-potto	Hiti-poto				
66	O-Hitte-toutouatu	Hiti-tutu-atu				
67	O-Hitte-toutounee	Hiti-tutu nei	....	15 30 to 20 0	178 W. to 177 E.	The Fiji group.
68	O-Hitte-toutou-rera	Hiti-tutu-rira				
69	O-Hitte-tai-terre	Hiti-tai-tere				
70	Te-Amaroo-hitte	Amaru-hiti				
71	Te-Atou-hiti	Atu-hiti	....	....	....	This appears to be the "Fiji Group," *atu* meaning a group.
72	Ouowhea	Uwhea	Uea	13 20	176 15	Wallis Island. There is a doubt as to whether the name Ouowhea is not misspelled, and that it was Onowhea originally. If so, this is intended for Niue, or Savage Island, and would agree with the position on the chart.
73	O-Tootoo-erre	Tutu-ere	Tutu-ila	14 20	170 50	Samoa Group.
74	Te-Orooroo-mativatea	....	....	....	....	
75	Wouwou	Wauwau	Vavau	18 40	174 0	Tonga Group.
76	Ooopooroo	Upuru	Upolu	14 0	171 40	Samoa Group.
77	Te-Errepoo-opo-mattehea	....	....	....	....	
78	O-Heavai	Havaii	Savaii	13 30	172 40	Samoa Group.
79	Tedhu-roa	Tuaroa	Tuaroa	....	....	Society Group.
80	O-Wanna	Ana	Anaa	17 27	145 30	One of the Paumotu Group. Chain Island.
81	Tata-hapai	Tata-hapai	Hapai	20 0	174 20	One of the Tongan Group. Tata is probably the word "near," and affixed to the name by mistake.
82	Tapy-ary	....	....	....	....	
83	Haedede	....	....	....	....	
84	Pappaa	....	....	....	....	

This list of islands shows clearly the extent of the geographical knowledge of the Tahitians prior to the advent of the white man. From the fact stated by Forster, that Tupaea himself had visited most of these islands, it is clear that the Tahitians retained their powers of navigation much longer than some other branches of the Polynesian race. The New Zealanders and Sandwich Islanders had certainly ceased to make long voyages for some twenty generations; and it is probable that the Samoans had done the same for many generations before the nineteenth century. The Tongans, Marquesans, and some others apparently still made extensive voyages down to the coming of the white man.

Sir Joseph Banks says of the Tahitian canoes, which he fully describes as he saw them in 1769: "In these, if one may credit the reports of the inhabitants, they made very long voyages, often remaining several months from home, visiting in that time many different islands of which they reported to us the names of nearly one hundred. They cannot remain at sea above a fortnight or twenty days, although they live as sparingly as possible, for want of proper provisions and places to store them in, as well as water, of which they carry a tolerable stock in bamboos." (Journal, p. 159.)

In reference to their knowledge of astronomy, by which they were enabled to make these long voyages, the same writer says: "In their longer voyages they steer in the day by the sun, and in the night by the stars; of these they know a very large number by name, and the cleverest among them will tell in what part of the heavens they are to be seen in any month when they are above the horizon; they know also the time of their annual appearance and disappearance to a great nicety—far greater than would be easily believed by an European astronomer." (*Loc. cit.*, p. 162.)

Captain Cook notes that the Tahitians gave him the names of 130 islands known to them.

In addition to the names mentioned on Tupaea's chart, and in the old Tahitian chants already quoted, M. De Bovis, a writer on Tahitian subjects, gives the names of the following lands to the west of Tahiti mentioned in their chants:—Te Miromiro, Pua-ura, Faa-nui, and Tonga-tapu, the latter no doubt being the principal island of the Tonga Group, and which is not alluded to in Tupaea's chart. Then we have the list of names embodied in "The Birth of new Lands," a chant published by Miss Henry in the "Journal of the Polynesian Society," vol. III, p. 136, wherein are included the names of a number of islands situated between Tahiti and Hawaii which no longer exist. This tradition was also given by Fornander in his "The Polynesians," from the Hawaiian point of view.

From what has now been stated, it is clear that the Tahitians, like many others of the Polynesian race, had a very extensive knowledge of the Pacific. It extended from Hawaii to New Zealand—about 4,000 miles—and from Mangareva or Gambier Island to near the New Hebrides, or perhaps further north-west—about 4,500 miles.

When we come to consider that the whole of this vast space of ocean was in former times traversed by various branches of the Polynesian race, and that they had no leading coast lines to follow, but must have steered boldly out into the ocean with but a small extent of land as an objective, after weeks of sail, we cannot but acknowledge that, as bold navigators, the Polynesians were far before any nation of antiquity in this art. Before such feats as theirs, the navigation of the Phœnicians, Arabs, Chinese, and others, sink into insignificance.*

No. 15.—THE OCEANIC FAMILY OF LANGUAGES.

By the Rev. D. Macdonald, D.D.

Read Tuesday, January 11, 1898.

PHONOLOGY, STRUCTURE, ORIGIN.

The Insular family of languages, or Oceanic, is spoken by thirty or forty millions of the human race, inhabiting islands in the Indian and Pacific Oceans and in the intermediate Malay Archipelago and Peninsula. The numberless languages, or dialects, of this family have all sprung from one inflected Oceanic mother-tongue, now lost, or existing only in these, its analytic or broken-down offspring. They have been divided into four groups, which it is convenient to recognise :—(1) The Tagalan, comprising the Tagala, Bisaya, Formosa, Marianne, Malagasy, &c. ; (2) The Malayan, comprising the Malay, Java, Battak, Dayak, Bugis, &c. ; (3) The Polynesian, comprising the Samoan, Tongan, Hawaiian, Maori, &c. ; and (4) The Melanesian, comprising the Fiji, Aneityum, Tanna, Eromanga, Efate, Malikula, Santo, Solomon Islands, &c. Taking a general view of all, we find that they have a common stock of numerals, pronouns, and other words, of formative or word-building suffixes and prefixes, and of

* Note.—The chart that accompanies this paper is from De Quatrefage's copy of Forster's chart.

grammatical or syntactical processes or sounds, which constitutes them one family. In order to ascertain the origin of this family, or its relationship to some other known family, as the Indo-European or the Semitic, these all must be taken into account, due regard being had to the principles of dialectic, phonetic, and grammatical variation, such as obtains in languages in the analytic stage, and due allowance being made for the length of time, and the circumstances in which the analytic process has been going on—in this case (say) four thousand years—in circumstances very highly favourable to diversification. If it can be shown that the common stock of numerals, pronouns, and other fundamental words, of formative suffixes and prefixes, and of grammatical processes and words, which constitutes the Oceanic languages a perfectly well-defined family, is Semitic, this will establish the relationship of these languages to the Semitic languages, and prove that the Oceanic mother-tongue was a sister-tongue to the Arabic, Phenician, Hebrew, Syriac, Assyrian, Himyaritic, and Ethiopic (with their modern dialects, as the Neo-Syriac, Mahri, Amharic, and Tigre), sprung, like them, from the no longer existing Semitic mother-tongue. The object of this paper is to show as briefly as possible that this can be done.

In treating the phonology of our subject, it is necessary to observe that the Semitic languages have certain gutturals peculiar to them, and that some of these occur—*e.g.*, in the numeral words—for 1, 4, 5, 7, 10, and 1,000. The Semitic gutturals referred to are *alif* represented in what follows by *a* or some other vowel in italic, and when it has *hemza*, which indicates that it is to be pronounced almost like *h*‘ (*ain*), by *a*‘ or other vowel with ‘; *ha* by *h*; *hha* by *h*’; the rougher Arabic *hha* by *h*”; *ain* by *h*‘; the rougher Arabic *ghain* by *h*“. As to their original pronounciation,* *a*’ was the lightest, softer than *h* which is represented by our *h*. The guttural *h*’ is stronger than *h*, something like *ch* in Scotch *loch*; it had a softer and rougher sound, the latter being represented in Arabic by *h*”. The guttural *h*‘ is unpronounceable by Europeans, and peculiar to the Semitic languages, akin to and sometimes confounded with *h*”. It had a softer and a rougher sound, the latter being represented in Arabic by *h*“, and described as the sound of a *g* slightly rattled in the throat, and resembling somewhat the Northumbrian *r* and the French *r grasséyé*. To these has to be added the Semitic *r*, which was sometimes pronounced as a lingual, and sometimes as a guttural with a hoarse guttural sound. For an account of these gutturals, and the trills *r*, *l*, see Prof. M. Müller's Lectures on the Science of Language, ii, pp. 135–138. It has to be added that the tendency

* The symbols here used are not to be regarded as at all denoting the true pronounciation; as to that, in the ancient and modern Semitic dialects the grammars of the various dialect must be consulted.

of the Semitic languages is, in the course of their analytic development, to confound these gutturals, and, finally, to soften them all down to *a'*, or a mere spiritus lenis. Dr. Codrington, speaking of the guttural trill, which he calls "the Melanesian *g*," says :—"It may be taken for *r*, or may be missed altogether. It has been written *g* (hard), *r*, *g* (*ngg*), *rg*, *h*, *rh*, and *k*. That it resembles *r* is shown by the spelling of visitors. . . . Bishop Patteson was struck by its resemblance to the Arabic *ghain* (*i.e.*, *h*"), and Professor M. Müller's description of the Hebrew *ain* (*i.e.*, *h*') as a vibration of the fissura laryngea, approaching sometimes to a trill, nearly equivalent to a German *g* in *tage*, closely suits it." (The Melanesian Languages, pp. 204-206). In Oceanic *r* is sometimes pronounced as a lingual, sometimes as a guttural (Crawford, Malay Gram., p. 75 ; F. Müller, G.d. Sprache, iii, ii, ii, p. 92ff) ; hence, as we shall see, we find it not only interchanged with *t*, *b*, *v*, &c., but also with *h*, *g*, (*k*), or spiritus lenis.

Interchanges with each other of dentals, sibilants, gutturals, labials, or of dentals with sibilants are not to be wondered at. But the more remarkable interchange in Oceanic between (1) dentals (or sibilants) and labials, and *vice versa*, (2) between dentals (or sibilants) and gutturals, and *vice versa*, and (3) between gutturals and labials, and *vice versa*, are not so easily understood. In (Melan. Lang., pp. 403-407) Rotuma *folu* 3, *hak* 4, *hif* 7, for the common Oceanic *tolu*, *bat*, *pitu* (and generally in the Oceanic numerals everywhere, as we shall see) all these interchanges are exemplified (1) in *folu*, *hif*, (2) in *hak*, and (3) in *hak*, *hif*. In Hawaiian, dental and guttural are confounded, and *k* stands for both *t* and *k*. In Tangoan Santo, dental and labial are confounded, as *t* and *p*, *m* and *n*. (South Sea languages, p. i). The same confusion is found in North East Malekula, where it is impossible sometimes to tell whether the native speaker utters *m* or *n*, *th* or *v*. In these cases one letter might represent both *th* or *v*, letter *t* or *p*, *m* or *n*, as Hawaiian *k* stands for *k* or *t*. In Efate *k* is very often pronounced *ng* and *t* as *r*, or *r* as *t*. In some cases *r* and *e* are confused. "It is a question whether the sound made in some localities is really an aspirate which may be written *h*, or not rather to be represented by *f*. . . . In the greater number of languages which have both sibilants and aspirates, *h* and *s* are equivalent." (The Melanesian Languages, pp. 193, 216.) Now, these interchanges must have been going on from the earliest times, as we find examples of them generally throughout the Oceanic dialects. Thus, in Efatese dialects "who?" is *fei*, *sei*, and *he* (Tahitian *vai*); and *bea*, 'first,' in one dialect, is *tiamia*, which is certainly for *miamia* or *fiamia*, Epi *beamu*, Samoan *muamua*. Efate *finanga*, food, is in Duke of York *winaga*, Mota *sinaga*, Motlav *hinag*. Star in Malay is *bintang*, in Javanese *lintang* and *wintang*, in

Malagasy *kintana* and *vasiana*, in Aneityum *moijeur*, in Efatese *masoei* and *ngmahe*. In Malay *nipis*, *tipis*, *mipis*, 'thin,' there is the interchange of *n* and *t*, and *n* and *m*; while in *tukul*, *pukul*, 'strike,' *kilat*, *kilap*, 'lightning,' is that of *t* and *p*. (Marsden, Malay Gram., p. 113.) In Malagasy, when a formative suffix is attached to words having the formative ending *-ka*, *-na* or *-tra*, the *k* is changed to *h* or *f*, the *tr* to *t*, *r*, or *f*, and the *n* often to *m*. (Parker, The Malagasy Language, p. 19.) The importance of this to the explanation of certain universal facts in Oceanic will appear below. The interchange of labial and guttural is seen in Malay in *gawa* or *bawa* 'to carry,' in Efatese *bui* and *kui* 'back,' *mafis* and *makus* 'knife,' Malay *piso*, Malagasy dialect *kiso* 'knife.' Dr. Codrington has remarked that in the letter-changes which do occur in the Melanesian it is generally impossible to find a law. (Work cited, p. 201.) Prof. M. Müller, after comparing Sanscrit *gharma*, 'heat,' with Greek *thermos*, Latin *formus*, says he is strongly inclined to ascribe the phonetic diversity which we observe between Sanscrit, Greek, and Latin to a previous state of language, in which, as in the Polynesian dialects, the two or three points of consonantal contact were not yet felt as definitely separated from each other. . . . No letter ever becomes. People pronounce letters, and they either pronounce them properly or improperly. (Science of Language, ii, p. 180-1).

THE NUMERALS (PHONOLOGY, STRUCTURE, ORIGIN).

In the Semitic languages the abstract or feminine of the numerals 3–10 was formed, as in other nouns, by the formative suffix *t*, or *th* (pronounced now by some Arabs *to*), which often became either a guttural *h* or elided. This feminine form of these numerals was used with masculine nouns, and has become in Modern dialects almost the sole form used and of common gender, and it is, therefore, the form to be expected, and which is found in Oceanic. This ending is unmistakably seen in the numerals 4 and 5, with which we begin, only premising that the nouns of the Oceanic languages and dialects of the four groups to which the following words belong, here omitted for the sake of brevity and clearness, may be found given in my paper in the Journal of the Polynesian Society, last quarter of 1896, pp. 215–222.

Four.

Arabic, *a'rbah'at*; modern, *arbaat*; modern Ethiopic dialects, *arut*, *ubah*; Oceanic, *ampat*, *mbit*, *evats*, *ebits*, *efatra*, *efats*, *efutchi*, *apat*, *hipat*, *vare*, *vas*, *vitu*, *vier*, *bātě*, *vavu*, *fiak*, *opak*, *emin*, *pali*, *fal*, *awang*, *kaar*, *tar*, *tas*, *tiak*, *thātě*, *thack*, *hak*, *hani*, the *t* elided; *fa*, *wha*, *a* in all the others is represented by this final consonant. Malagasy *efatra* is *efara* in *hefarana*, &c.

Seven.

Arabic, *sabh'atu;* Assyrian, *sibit;* Mahri (Modern Himyaritic), *ibet;* Oceanic, *pitu, fito, fiz, fuz, fik, sik, tik, titu, tuju, fiet, fiak, ambitu, wontit, awith.* The final consonant in all is the ending *t.*

Six.

Arabic, *sittat;* Mahri, *iteet* (*itit*); Oceanic, *enina, anam, anum, innem, wonen,* (*won*), (*kon*), (*fene*), (*hene*), (*hono*), *gurum;* Malagasy, *enina* is *enima* in *enimina,* &c. In all, except those in brackets, in which it is elided, the final consonant is the ending *t.*

Nine.

Arabic, *tish'at;* (Modern, *tisà*); Mahri, *iset;* Sokotra, *sa'ah*); Oceanic, *siam, sivy, hiva, hhepi, iva, siero, siera, siyu, tiku, sin, sanga, asera, salapan, sambilan, pitan.* In *salapan* we have labial for sibilant (as in *fene,* 6; *wontit,* 7; *puluh,* 10; and often), and *sala*—is the initial *t* reduplicated exactly, as is *dala* (or *bala*) in Malay, *dalapan* (also *salapan*), 8; Lagala *dalara,* 2. *Sambihan* appears by transposition for *saliban* (= *salapan*). In all, the final consonant is the ending *t.*

Eight.

Arabic, *thamaniyat;* Modern *thmani;* Hebrew, *shemonet;* (Sokotra, *tamani*); Oceanic, *lapan, dalapan* (and *salapan*), *wan, wal, panu, valu, varu;* the ending *t* elided in all.

Three.

Hebrew, *shiloshah;* Arabic, *thalathat;* Modern, *thlata,* or *thĕlata;* Modern Syriac, *telaa;* Oceanic, *telo, talu, tolu, rolú, folu, silu, teni, kar, rei, seik, tiga. Seik* and *tiga* are for *thelata* by elision of the middle *l* and *g* or *k* for the final radical *t.* In all, the ending *t* is elided.

Two.

Arabic, *thinta* (*ni*); Hebrew, *shita;* Himyaritic, *thita* (for *shinta, thinta*); Oceanic, *duwa, rua,* or *tua* (that is, *ruwa* or *tuwa*), *roa, duka, riea, ruka, dia, rowah, ua, lua, nuwa,* and first syllable reduplicated, *dalava, darua.* The formation ending *ta* in *thinta, thita,* is a double ending, consisting of the Semitic feminine *t* and the Semitic dual ending *a,* and is exactly represented according to rule in Oceanic by the last syllable of *riea, ruwa* (*rua*), *dalava, duha.*

One.

Arabic, m. *a'h'ad,* f. *wah'idat;* Syrian m. *h'ad,* f. *h'ada, h'a;* Hebrew m. *a'h'ad,* f. *a'h'ath;* Ethiopic, m. *a'h'adu,* f. *a'h'ati,* Ligri, m. *ade.* In *h'a, ah'ath, ah'ati* the *d* is elided. Oceanic; *aida, aisa, ida, ita, isa, asa* (and *sa*), *iray, tas* (and *rais*), *rari,*

tasi, *taday*. In the following the final consonant represents, according to rule, the original ending *t*:—*Iraika*, *isaka*, *saka*, *dik*, *san*, *isara*.

Five.

Arabic, *h'amsat*; Modern, *h'amsa* or *h'amse*; Mahri, *h'omo*; (Sokotra, *h'emah*); Oceanic, *hima*, *himah*, *ima*, *yima*, *lima*, *rima*, *tima*, *kima*, *sima*, *rime*, *dimy*. The ending *t* and radical *s* elided in all as in Mahri.

Ten.

Arabic *h'asharat*, Modern *h'ashra*, Ethiopic *h'ashartu*, Hebrew *h'asarah*, Oceanic *ngahuru*, *garula*, *ahuru*, *ngabulu* (sa) *chbulu*, *nngaviri*, *ngatil*, *abur*, *folo*, *puluh*, *buro*, *furu*, *novulu*, *napulo*, *mapuru*, (si) *nafulu*, (sa) *ngpuvu*, (sa) *nghul*. The peculiar Semitic guttural *h'* is here represented in Oceanic by *g* (as sometimes in the Septuagint version of the Bible, 3d century B.C,), by *ng* (as now is pronounced among the Jews), and by the guttural *ch*, as well as by *n* and *m*. In all, the ending *t* is elided.

Hundred.

Arabic *mia't*, with nunation *miatun*, Modern *mayat*, Ethiopic *me'et*, Amharic *mato* (the *t* is the feminine ending *t*), Oceanic *mari*, *mara*, *bot*, *fok*, *puku*, *lutcho*, *ratu*, *rato*, *ngut*, and, with nunation, *hutun*, *utin*, *natun*. For similar changes of *m*, see below. In all, the ending *t* is the final consonant.

Thousand.

Arabic *a'lef*, with nunation *a'lefun*, Hebrew *a'lef*, Assyrian *alapu*, Mahri Ehkili *of*, Oceanic *arivo*, *libu*, *livu*, *ribu*, *söbu*, *rewu*, *ewu*, *afe*, and with nunation, *ribun*, *rebun*, *ruwun*.

The following belong to the common stock of Oceanic words, and the letter changes they exhibit are to be compared with those we have seen in the numerals. Compare the changes of the initial *m* in the four following words with those seen in the word for "hundred."

Water.

Arabic, *maa't*, Modern and Ethiopic, *mai*; Oceanic, *vai*, *fai*, *wai*, *ai*, *be*, *pei*, *tei*, *rei*; Gilolo, *wayr*; Malay, *ayer*. The last two still retain the ancient feminine ending *t* as *r*.

Banana.

Arabic, *ma'z'*; Amharic *muz*; Oceanic, *muhu*, *bus*, *butch*, *hutshi*, *hotsy*, *āts* or *at*, *muku*, *loka*.

The two following words are of grammatical importance, being used as the analytic substitute for the ancient inflexion of gender in nouns.

Man (vir).

Arabic, *mara'*; with nunation *mara'un*; Aramaic, *mare*, *mar*; Oceanic, *mera*, *muera*, *mane*, *mani*, *mano*, *man*, *ngane ānui*, *āne*, (in *tangane*, *taane*); (*l* for *m*), *langai*, *lacay*, *laki*, *lahy*, and with nunation, *burani*, *muwani*, *lanan*.

Woman.

Feminine of preceding word. Arabic, *marat*, *mar-a't*; Oceanic, (see for the same changes of the ending *t* above under the numerals, 4, &c.) *baluk*, *puran*, *bran*, *ngaruni*; and the middle *r* elided, *but*, *bite*, *matu*, *fid*, *vek*, *bine*, *fine*, *buan*, *bien*, *wien*, *pain*; ending *t* elided, *farri*, *ngarui*, *urao*; both *r* and *t* elided, *mua*, *bai*, *bayi*, *vy*; *l* for *m*, *lewa*, *alewa*, *iluai*, *lai*, *lio*; re-duplicated *parampuan*, *parawan*, *pilaven*, *mavek*, *faifid*, *fafine*, *mahine*, *babayi*, *bavy*, *babin*, &c.

These foregoing words—hundred, water, banana, man, woman—beginning with *m*, show the *m* changed to *l*, *r*, *n*, &c. The following word shows initial *l* changed to *m*, *n*, *r*.

Tongue.

Arabic, *lisan*; Hebrew, *lishon*; Matori, *lesa*; Oceanic, *lidah*, *litah*, *lela*, *rero*, *lapi*, *lapu* (of the *p* in Salapan, 9), *leme*, *neme*, *meme*, *mena*.

The following words, down to that for "ears," have as their initial letter one of the original four peculiar Semitic gutturals like the numerals 1, 5, and 10, and showing the same phenomena of change to *r*, *l*, *t*, *k*, *n*, *ng*, and *m*, and to a spiritus lines or elision.

Father.

Arabic, *a'bw*; Hebrew, *a'b*, *a'v*; Aramaic, *aba*; Oceanic, *rama*, *ray*, *tama*, *rema*, *kama*, *ab*.

Mother.

Arabic, *u'm*, and *i'mu* (Malay *ibu*); Aramaic, *ima*; Tigre, *ena*; Oceanic, *reny*, *rena*, *tina*, *sina*.

Time.

Arabic, *a'ny*, *a'n*; Oceanic, *rani*, *rang*, *lang*, *nang*, *dan*.

House.

Arabic, *h''aimat h''aima*; Oceanic, *huma*, *luma*, *suma*, *kom*, *uma*, *ima*, *lom*, *om*.

Testicles.

Arabic, *h''isy h''usyo*; Oceanic, *rass*, *laso*, *rasi*, *àsi*, *luho*.

Fire.

Syrian, *h'ab* to burn (fire); Arabic, re-duplicated, *h'ubah'ibu*, fire; Oceanic, *gabu*, *kabu*, *api*, *afy*, *habu*, *rahi*, *lahi*, *lap*, *yap*, *sembi*.

Rain.

Arabic, *h''a'th'*, with nunation, *h''a'thurs*; Oceanic, *uth*, *auf*, *omo*, *komah*, *gefa*, *usa*, *bosi*, *medu*, with nunation *ujan*, *udan*, *roana*.

Yam.

Arabic, *h''ayab'*, roots, wurzel; Oceanic, *yubi*, *uwi*, *ubi*, *uvy*; Malekula, *rum*; Samoan, *ufi*. With this compare—

Bury (verb)

Arabic, *h''aba*; Malekula, *rum*; Samoan, *ufi*.

Tree, stick, wood.

Hebrew, *h'ets*; Arabic, *h'assa* (stick); Ethiopic, pl. *h'etsu*, *a'h'etsu*; Oceanic, *hazo*, *kasu*, *kayu*, *kau*, *yesi*, *kaan*, *lakai*, *la'au*.

Stone.

Hebrew, *e'ben*, or *e'ven*; Ethiopic, *e'ben*, pl. *a'e'ban*; Oceanic, *vet*, *fat*, *fatu*, *veru*, *batu*, *vato*, *kohatu*, *pohaku kapir*, *kabil*.

Water (Spring.)

Arabic, *h'anu*; Hebrew, *h'an* (eye, fountain, spring); Oceanic, *rano*, *ran*, *honu*, *tanu*, *fanu*, *ranu*, *lanu* (lake). The plural of this Semitic word signifies—

The Eyes.

Arabic, *a'h'yunat*; Ethiopic, *ah'ynt*; Hebrew, *h'ayanoth*, *henoth* (fountain); Oceanic, (final *t* elided), *tano*, *nana*, *tun* (*n* to *m*), *hama*, *rama*, *lumo* (initial guttural elided), *nata*, *nero*, *mata*, *meta*, *masu*. This final *t*, the *t* of the Semitic feminine plural, is the same *t* already seen as the feminine or abstract ending.

Teeth.

Arabic (Semitic broken plural, or "pluralis fractus"), *a'sunri*, *a'sinnat*, or *a'sinne*; Oceanic, *kasinga*, *lesin*, *nifan*, *ngipin* (final *n* elided), *ngidi*, *bati*, *ngisi*, *nisi* (*s* to labial), *nify*, *ribo*, *livo*.

Hands (the two.)

Arabic, (dual) *yadan*, and *a'dan*; Oceanic, *tanana* (for *tadana*), *tangan*, *parian*, *patay*, *peni*, *fahan*, *pan*, *mareh*, *vira*, *kanei*, *karah*, *vara*, *aru*, *faru*, *uada*.

Ear, the Ears.

Aramaic, (*a'dĕna*); Arabic, pl. *a'than'*, or *a'thanu*; Oceanic, *tadiny*, *talinga*, *taringa*, *riringa*, *tikngа*, *karinga*, *karin*, *falian*, *boronga*, *boro*, *tananu*.

The Semitic guttural *r* we have already seen elided, or changed to *k*, *h*, as in *laki*, *lahy*. See word following.

Head.

Hebrew, *rosh* ; Arabic, *raasu* ; Oceanic, *lori, loha, lova, hulu, uru, alu, karu, paru.*

Note the changes here of the *s* or *sh* to *r*, *l*, *h*, and a labial, as in the following word.

Hair.

Arabic, *shah'ru* ; Oceanic, *huru, hili, lulu, firi, vili, bulu, volo.*

The following two words show the interchange of guttural and labial—

Swine.

Arabic, *k'abbah'* ; Oceanic, *babi, puaka, wak.*

Bow.

Arabic, *k'asu* ; Oceanic, *hisu, husu, āsu, vus, pasi, pana, fana, vini.*

Moon.

Ethiopic, *wareh'*, or *varah'* ; Mahri, *wurit*, &c. ; Oceanic, *bulan, volana, bulak, bulet wurah, mohok, mokwa, bughan, vula.*

Lightning.

Hebrew, *barak* ; Oceanic, *bilak* ; Malay, *kilat* or *kilap* ; others *hilatra, bila, wila.*

Liver.

Ethiopic, *kabdí* or *kavdĕ* ; Amharic, *hode* (if *arut*, 1) ; Malagasy, Malay, Samoan, Efate, *ātĕ* or *āty.*

The following two words are examples showing little change—

Earth, ground, soil.

Arabic, *tano* ; Oceanic, *tano, tany, tana.*

Sea.

Arabic, *tas'* ; Oceanic, *tasi, tahi, tai.*

The foregoing words, except the last two, have been given, not because of their identity of sound, but because of the striking phonetic changes they exhibit. These changes could never be accounted for till the manner in which the peculiar Semitic gutturals are represented in Oceanic was investigated. The obvious error into which one fell was to expect to find these gutturals as they are in the most analytic modern Semitic dialects, —that is, as a more breathing or spiritus linis so elided ; whereas the facts show that in the Oceanic mother-tongue these gutturals had the same strong and varying peculiar pronunciation as in the other ancient Semitic tongues. This comes out clearly also in the pronouns, as we shall now see.

THE INTERROGATION PRONOUN.

Who? Which?

Arabic, *a'yy;* Ethiopic, *a'y;* Oceanic, (*i*) *sei*, (*i*) *za*, *ba*, *me*, *vai*, *hai*, *wai*, *ai*, *hei*, *tei*, *oi*, *thei;* Efate, *he*, *sei*, *fei*.

Which? What?

Arabic, *a'yyuma*, contracted *a'ma;* Modern, *a'ma*. This is the preceding word joined with the Semitic interrogations *ma* (Himyaritic *ma*, or *ba*, what?); Oceanic *zoog* and *(ovy)*, *sapa* and (*apa*), *safa* and (*sā*), *naf*, *ava*, *aha*, *ā*, *hava*, *sav*, *hav*, *thava*, *taha*, *neva*.

THE PERSONAL PRONOUNS.

I.

Arabic, *a'na;* Assyrian, *a'naku* (original form); Oceanic, *hina*, *hanu*, *kena*, *kinau* (for *kinaku*), *haku*, *aku* (and *daku*), *aho* (and *zaho*), *rehu*, *lau*, *laku*.

Thou.

Arabic, m., *a'nta* (and *a'nka*, *a'ka*, as in this pronoun in the Semitic mother-tongue *t* and *k* were confused as they are often by little children); Oceanic, *ik*, *nik*, *hica*, *hanta*, *ang*, *daka*, and see the first person plural inclusive below.

You.

Arabic, m., *a'ntum* (Modern also *a'ntu*), and *a'nkum*, *a'kum;* Amharic, m. and f., s. and pl., *a'ntu;* Modern Syriac, m. and f., *ah'ton;* Oceanic, *akam* or *akamu*, *kamu* (used also for singular) *dakau*, *angkau*, *kangkau*, *hanao*, &c. Owing to this practice of using the plural for the singular (you for thou), the Semitic demonstrative plural *ala*, these or those, was joined with this personal pronoun, and also that of the third person, to denote exclusively the plural, as *hanare* (*hano*, thou or you, '*re* these), so in Amharic is used *alant* (*ala* these, *anta* thou.)

In the pronoun of the third person the ancient Oceanic plural is used now for both singular and plural, and generally with this plural demonstration to denote the plural exclusively.

They (and used for singular in Oceanic, and often in modern Syriac).

Masculine, Arabic, *hum;* Hebrew, *hem;* Assyrian, *sun;* Himyaritic, *sum*, *hum;* Aramiac, *hinum*, *i'num;* Modern Syriac, m. and f., *ani*. In the Semitic mother-tongue the initial letter of this word was pronounced *s* and *h*, which finally became also *i'*; and the final *m*, the plural ending as in the second person, and as in masculine nouns, was in like manner interchanged with *n*. This *m* or *n* was also apt to be, and sometimes was, elided. Thus

we have in Malay *inya* and *iya* (Samoan *ia*), and *diya;* Tagala, *siya;* Malagasy, *zy* (for *zini*, as the suffixed pronoun *ni* also proves); Malekula *hini*. To denote the plural exclusively we have by the means already explained Tagala, *sila;* Malagasy, *zare-o;* Malekula, *hiniri*.

It should be observed that as the *m* in *akam*, *kamu*, *ye*, is the *m* of the Semitic plural ending, so the *n* of *hini*, *inya*, is the same ending changed to *n* as it was from the earliest times in the Semitic languages, both in the pronouns and masculine plural nouns. The Oceanic mother tongue, therefore, had this plural as well as the feminine plural ending seen above in the word *mata*, the eyes. In modern Oceanic as in the nouns, so in the pronouns of the second and third persons, the distinction of gender has been dropped as in the same (plural) pronouns in modern Syriac.

We.

Hebrew, *a'nah'nu*, the pronoun of the first person singular reduplicated—literally, I + I = we. This is the nearest extract form of the word to that of the Semitic mother-tongue; and even in Hebrew we have for it the more contracted form *a'nu*. In the Oceanic languages it is the first part of the first person plural exclusive and inclusive, the second part being the pronoun third plural in the exclusive, and that of the second singular in the inclusive; thus Efate, *kina-mi*, or *kini-mi*, we + they = we exclusive of thou, and *kini-ta*, or *kin-ta*, we + thou = we inclusive of thou; Malay, *ka-mi*, *ki-ta;* Malagasy, *zaha-y*, and *si-ka* (for *zi-ka*). That *zaha* is for *zahna*, the suffixed pronoun *na* in *na-y* proves, and *zahna* exactly corresponds letter for letter to the modern Arabic *a'h'na*, we.

GRAMMAR OF THE PRONOUNS.

The abbreviated suffixed and prefixed pronouns belong to grammar, and for the sake of brevity it may suffice to point out here, as showing the grammatical correspondence, that suffixed to verbs they express the nominative, as Ethiopic *ku*, Malay *ku* Malagasy *ho*, I; Ethiopic *kemu*, Malay *kamu*, you, suffixed to nouns they express the genitive, as Ethiopic *kemmu*, Malay *kamu*, your, or of you. This is really the Semitic "construct state," expressing the genitive, seen not only in the suffixing of the pronoun to a noun, but also in the placing of one noun immediately after another in this genitive construction. It is exactly so in the Oceanic, both with pronouns and nouns. In the Semitic languages very abbreviated forms of the pronouns were used prefixed to the verb to denote the nominative; thus in all of them the pronoun of the first person singular was shortened to *a'*, which in Efate is also *a*, not however prefixed to, but before, the verb, though never used except with the verb, and therefore called the verbal pronoun.

THE VERB.

The Semitic finite verb was in its origin a participle (verbal adjective) or infinitive (verbal noun of action) with the abbreviated pronouns prefixed or suffixed to denote persons and number. From the finite verb participles and infinitives were again derived. In accordance with this, these derived participles and infinitives, with the separate pronouns, abbreviates, or not abbreviates, were often used for the finite verb. This analytic substitute for the finite verb tended to become more commonly used as the language became more analytic, as for instance in Aramaic and modern Syriac. Thus the Oceanic verb, as we now find it, has originated, being generally a derived participle or infinitive. An example will show clearly what is meant, or the relation between the modern Oceanic and the ancient verb. The verb "to fear" in Arabic is *tak'a*, from which was divided the infinitive *tak'iyat* a fearing or being feared, the Semitic infinitive having both an active and a passive sense. The simplest form of this verb in Oceanic corresponds, not to *taka*, but to *takiyat*, and is seen in Malay *takut*, Malagasy *tahotra*. *Tahotra* is a noun, fearing or fear, and is made into a verb by formative prefixes to be after considered—as *matahotra*, to fear, Efate *mataku*, Samoan *mata'u;* but in Malay *takut* is noun, verb, and adjective, fear, fearing or afraid, and to be fearing or afraid. Thus *akutakut*, I fear, or am afraid, is literally, I (am) fearing, or I (am) being afraid.

The formative abstract and adjective endings.

The simple or shortest form of the Oceanic verb being *takut* or the like, it became necessary to form it verbal nouns (infinitive) and verbal adjectives (participles), as *takiyat* (*e.g.*, had been) formed from *taka*, or by suffixed formatives. In the Semitic languages there were two abstract and two adjective endings. The adjective endings were *an*, or *ana*, or *na* and *i*, and the abstract endings were *t* (as in *takiyat*), and *an*, *āna*, or *ōn*, or *nā*. All these forms having *n*, originally formed adjectives, and these cause to form abstract nouns also. They were also combined *i* and *t* forming abstracts in *it*, *t* and *n* adjectives in ton (*e.g.* Hebrew from the verb *h'akal* was derived *h'akalut* a being crooked, crookedness; then the adjective *h'akalton*, crooked), and *tanga* forming nouns and adjectives in Amharic. In Oceanic these are used thus: Malay, *takutan* a fearing, fear; Malagasy, *atahorana* verbal noun, *atahorina* verbal adjective; Samoan, *mata'utia*. Here *ia* corresponds to Malagasy *ina*, and as both *ia* and *ina* are used alike; thus in Samoan we may infer that the Polynesian verbal adjective ending *ia* is for *ina*, by elision of the *n*. Compare for this elision the pronoun, Malay, *inya*, or *iya*. This *ia* or *ina* does not occur in Malay or Efate; but *ina* as an adjective ending is seen in Duke of York, *rumaina*—housey or full of houses—from *ruma*, house; and *na* or *ana*

occurs as an adjective ending in Efate, as *rana* branchy, branching, from *ra* a branch; and the Efate adjective ending *a*, as *koá* rooty, from *ako* root, seems to be this *na* or *ana* by the elision of the same *n*. If so, the Polynesian *a* differs from *ia* only in not having the *i*—that is, *ia* or *ina* is a combination of the two endings *i* (the Semitic adjective ending *i*, and this other Semitic adjective ending *na* or *ana*). The Polynesian *a* is certainly an adjective ending, as it forms adjectives from nouns—thus Samoan, *elee'ea* dirty, from *eleelea* dirt; and the Oceanic *ina* is no less certainly an adjective ending as it does the same, Malagasy *ozatra* a muscle, *ozatina* muscular, *somatra* beard, *somorina.*

Compare Samoan *mala*, a calamity, *malaia* unfortunate, bearded. Thus the "passive participles" in Malagasy in *ina*, and in Polynesian in *ina*, *ia*, and *a* are verbal adjectives formed from the verb by these adjective endings.

Corresponding to the verbal noun *takutan*, *atahorana*, is Efate *matakuāna* or *matakuān* (for *matakutan*); and in all cases, in Samoan this verbal noun formative is *anga* (Hawaiian *ana.*) It remains now to point out the changes the *t*, seen in *takiyat*, has undergone in different words or with different combinations of letters. As it is the same ending *t* seen above in the numerals, so it has undergone the same changes as those we have ascertained there. It commonly occurs in Malagasy *tr* (as in *tahotra*), *k*, *n*; and as has already been mentioned as a commonplace of Malagasy grammar, when *ana*, and *ina* are suffixed to it (as in *atahorana*, *atahorina*), *tr* appears as *t*, *r*, or *f*; *n* as *or* or *m*; and *k* as *h* or *f*. It appears also as *s*, and these variations of this ending *t* are found generally in Oceanic, as the following comparative table will show:—

	Malagasy.	Polynesian (Samoan).	Malay.	Efate.
Verbal noun—	tana	tanga	tan	
Verbal adjective—	tina	tia		
,,	rana	langa	ran	
,,	rina	lia		
,,	fana	fanga	pan	
,,	fina	fia		
,,	nana		nan	
,,	nina			
,,	mana	maga	man	
,,	mina	mia		
,,	hana	‘anga	han	
,,	hina			
,,	sana	sanga	san	
,,	sina	sia		
,,	ana	anga	an	an, ana.

Thus, Malagasy, *taratra*; Samoan, *tilo*; Maori, *tiro*, to spy, look at; we have Malagasy, *tarafana*, *tarafina*; Maori, *tirohanga*; Samoan, *tilofia*. The change of this *t* to a labial is seen also in Malay, *lakat*, or *lakah*; Malagasy, *rehitra*; Efate, *liko*, or *likot*,

to adore; Malagasy, *minona* (*minomana*, *minomina*): Samoan, *inu* (*inumanga*, *inumia*); Malay, *minum* (*minuman*); Efate, *minu*, or *munu* (*munuan* for *munutan*), to drink. To die, death, dead: Malagasy, *maty* (*hafatesana*); Malay, Efate, *mati* (*matian*); Mangarura, *mate* (*materanga*). It is quite clear that *matĭan* is for *matĭtan*, and that *mati* corresponds, not to Arabic *mata*, indeed, but to its infinitive *matĭt*, a dying or being dead. One or two more examples must now suffice. Arabic, "*asha*, he lived, infinitive,—"*aishat*, a living or being alive; Mota, *esu*: Malagasy, *velona* (*velomana*, *velomina*); Malay, *idup* (*idupan*); Java, *urip*; Samoan, *ola* (*olatanga*, *ola'anga*); Tanna, *murif*; Efate, *moli* (*molian* for *molitan*, like *mate* for *matitan*, and *matakuan* for *matakutan*, and *munuan* for *munutan*). Arabic, *a'thàna*, *a'thina*, to hear, perceive, infinitive, *a'thànat*; Malagasy, *reny* (*renesana*, *renesina*); Samoan, *longo* (*longoina* for *longotina*); Malay, *dangar* (*dangaran*); Efate, *rongo* (*rongoan* for *rongotan*). See the word "ears," above, in which the initial guttural of this stem is retained in Oceanic. It falls away in the verb, according to a Semitic law, owing to the influence of the ending *t*, as does the initial guttural of the word, Arabic, *h'alaka*, to adhere; infinitive, *h'alàkat*, *lakat* (and *lakap*), *rehitra*, *likot*, or *likut* (see above).

FORMS OF THE VERB. FORMATIVE PREFIXES.

These suffixes formed nouns (infinitives) and adjectives (participles). The prefixes now to be considered formed verbs from nouns, or derived verbs from verbs, usually called forms (or "conjugations"). These were three:—

1. *a*—Arabic, Ethiopic, Aramaic, originally *sha*, *sa* (*ta*, *ti*); Hebrew, *hi*; Himyaritic, *sa* and *ha*: Causative.

2. *n*, *in*, *i*—Arabic, Ethiopic, Assyrian, Hebrew: Reflexive, reflexive-passive reciprocal.

3. *ta*, *it*, *ith*—Arabic, Assyrian, Hebrew, &c.: Reflexive.

These three were combined thus:—

4. *an*—Ethiopic,* Amharic, Himyaritic, *han* (Halevy, p. 41); also Amharic, *asan* (for *san*): Causative-reflexive, or simply causative, or transitive (1 and 2).

5. *ata*, *ista* (for *sata*), *asta* (for *sata*), *satha*, *hatha*, or *hath*, Arabic x.: Causative-reflexive, simple causative, &c. Tigre, Amharic, Ethiopic, Himyaritic (1 and 3).

6. *nith*, *inta*, *itta*—Assyrian, Himyaritic: Reflexive-passive, or reciprocal-reflexive (2 and 3).

* Dillmann, Gr. Eth., §§ 73, 87. He remarks that this is in more frequent use in Amharic, referring to Isenberg's Amharic Grammar, pp. 54 (xxiv, should be xxiii), 56 (vii-x), 60 (vii, should be vii-x). Isenberg remarks, p. 56, that these verbs ix, x (*an-*, *tan-*) are very numerous.

7. *tan*—Ethiopic, Amharic: Reflexive-passive (3 and 4. See note on 4).

To these infinitives and participles *m* was prefixed, and then this participle or infinitive came to be used, sometimes for the finite verb. Thus we have *ma*, Syriac (Maphel), causative for the common *a*-, as in 1. Modern Syriac, almost the sole form of the causative. (Stoddart's Grammar, pp. 110–111.)

8. *ethma*—Syriac: Reflexive-passive (3 and 1).

9. *ma*, *m'*, prefix to infinitives of ground-form, and to passive participles of ground-form and derived-forms. Thus in Mahri the common passive participle is expressed through *m'*-, which replaces many lost inner passives. (See Von Maltzan on the Mahri, in Z. D. M. G., vol. xxvii).

With these compare the Oceanic:—

1. Dayak, *ma;* Macassar Bugis, *pa;* Efate, *ba*, *fa;* Malagasy, *a*, *ma;* Mota, *va;* Lifu, Mare, *a:* Causative.

2. Dayak, *in*;* Tagala, *i;* Malagasy, *i*, *mi;* Efate, *bi*, *fi;* Fiji, *vei;* Samoan, *fe:* Reflexive-passive, reciprocal.

3. Macassar, Dayak, Fiji, Efate, &c., *ta;* Malay, Java, Fiji, Efate, &c., *ka;* Dayak, *ha;* Fiji, *ra:* Reflexive passive.

4. Malagasy, *an*, *man;* Malay, Tagala, Dayak, &c., *man;* Malay (Malagasy), *san*. The *n* is often changed for euphony to *ng*, &c.; see the grammars: Causative, transitive.

5. Malagasy, *aha*, *maha;* Tagala, *mag*, *maka;* Macassar, *paka;* Efate, *baka*, *faka;* Fiji, *vaka;* Maori, *whaka;* Samoan, *fa'a;* Malay, *bâr:* Causative-reflexive, causative, reflexive.

6. Malagasy, *iha*, *miha:* Reflexive.

7. Dyak, *tan* (Malay, Malagasy, *tan*): Reflexive of 4. The *n* changed for euphony as in 4.

8. Malagasy, *tafa;* Dayak, *tapa;* Efate, *taba;* Oba, *tama;* Mota, *tava:* Reflexive, or passive, of 1.

9. Efate, *ma*, *mi*, *m';* Malagasy, Tagala, *ma;* Solomon Islands, &c., *ma* (The Melanesian Languages, Dr. Codrington, pp. 183–4): Passive.

To these must be added:—

10. *tar*, Malay: Reflexive-passive of 5, formed from (*b*)*ar*, as *tan* from *an*, (*m*)*an*.

Other combinations in Oceanic of these three prefixes (there are only three) need not here be noticed, as—

11. *ifa* (2 and 1), *ifan* (2 and 4), Malagasy; Reciprocal.

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* This *in* is also "infixed" between the first and second radicals of the verb in Javanese, Malagasy (The Malagasy Language, Parker), &c. In like manner *ta* (3) was infixed in Himyaritic and Assyrian, and *tan* (3 and 2) in Assyrian. In Arabic this *n* was infixed, but between the second and third radicals of quadriliterals.

In the light of the preceding phonological facts, the letter-changes here are not only according to rule, but, in such constantly used inflexional particles, very slight, as *t* to *k*, *h*, and to *r*, *g*; the elision of *n*; and the change of *m* to *b*, *f*, *v*, *p*. As to signification, the consonance is even more remarkable, of 1 with 1, 2 with 2, 3 with 3, 4 with 4, 5 with 5, 6 with 6, 7 with 7, 8 with 8, 9 with 9. The conclusion is that they are identical; and let it be observed that these prefixes, together with the before dealt with suffixes *ān*, *ina*, *na*, *ana*, *ia*, *a*, constitute virtually the whole of the Oceanic living inflexional material, these external inflexions having, according to the law of the analytical development of the Semitic languages, increased in frequency of use so as to replace the lost (as living) internal inflexions.

The object of this paper was stated as to show as briefly as possible that the common stock of numerals, pronouns, and other fundamental words of word building or formative prefixes and suffixes, and of grammatical or syntactrial words and pronouns, which constitutes the Oceanic languages one perfectly well-defined family, is Semitic, thus establishing the relationship of the Oceanic to the Semitic family of languages. I now submit that the foregoing being substantially correct, allowing for any possible errors of detail, this has been done, or at least it has been shown conclusively that it can be done; for it has been shown that the Oceanic mother-tongue had the peculiar phonology, the peculiar triliteral numerals and other words with, of course, their peculiar inflexion of internal vowel change, the peculiar nunation the peculiar dual feminine ending, the peculiar plural masculine ending, and singular feminine ending, the peculiar formative, abstract, or infinitive endings and formative adjective endings, the peculiar pronouns with their grammatical use with verbs and nouns, and the peculiar formative or verb building prefixes of the Semitic family of languages.

It remains to make a few concluding remarks on the foregoing. As to the method, it will be admitted that the numerals, pronouns, and other words, the word building or formative particles, and the phonology, though set forth in a paper like this necessarily in the briefest possible manner, yet even as thus set forth, show sufficiently for the purpose in hand the individuality of the Oceanic family of languages. Nor will it be disputed that the method of taking account of all of these, as stated at the outset, and not of a part only, is the right method; for instance, all the twelve numeral words given are certainly and purely Oceanic. Therefore, it has to be shown, in order to establish the relationship of the Oceanic to some known linguistic family, that all of them belong to that family. This method, which has been carried out in this paper, was not carried out by Max Muller, A. H. Keane, and Bopp, in endeavouring to establish the

relationship of the Oceanic to the Siamese, Canobodian, and Indo-European respectively; for instance, Muller and Kean did not find a single Oceanic numeral word in Siamese and Cambodian, and after the most careful investigation of these twelve Oceanic numeral words, Bopp could find only six which he deemed identical with the corresponding Indo-European numeral words; of the personal pronouns, only those of the first and second persons with the Indo-European of these persons; of the formative suffixes, only possibly and doubtfully one with an Indo-European suffix, and of the formative prefixes none he deemed identical in Indo-European. Now, not to mention other things, these formative prefixes are a well known distinctive feature of the grammatical structure of the Oceanic family, and so important that any method that not only does not account for all of them as is done above, but not even for one of them, is plainly inadequate; also, in the method of this paper no use of or reference to "roots" is made. All the Oceanic words are formed words, and as such are compared both as to phonisis and meaning with the corresponding formed Semitic words, this being deemed the right method. Not so with Bopp. For instance, the Oceanic word *tasi*, the sea, is compared with the Arabic word *taō* or *tasu*, the sea; but Bopp compares it with the Sanscrit root *sić* (or *sik*), to moisten, whence *sikta*, moisten, *sićaka*, cloud, in which, to say nothing more, the meaning is not the same.

It is worthy of special notice that the Indo-European pronouns of the first and second persons only five of the six numeral words compared by Bopp with the Oceanic, namely, those for 2, 3, 4, 6, and 7, are the Indo-European pronouns and numerals, usually compared with the corresponding Semitic as remarkably alike, while it is admitted that such resemblances, which may be casual, do not establish the relationship of the Indo-European to the Semitic family. In order to that, the grammatical structure of the two families must be taken into account; and as to grammatical structure, proof is not found either between the Indo-European or the Semitic, or between the Oceanic and the Indo-European, but is found, as has been pointed out, between the Oceanic and the Semitic. Assuming that the facts substantially are as have been set forth in this paper, then it is absolutely certain, not only that the Oceanic words and formative particles dealt with are purely the words and particles of the distinctively Semitic stock, but also that the characteristic grammatical structure as a whole of the Oceanic is that which as a whole is distinctively and exclusively characteristic of the Semitic family of languages. I may here add that the peculiar gutturals, or the guttural phonology, of the Semitic family of languages is an important part of this whole—that is, of this distinctive or exclusively characteristic grammatical structure;

and that this part also is duly represented, as has been shown above in the Oceanic. Because of this, special prominence has been given to these gutturals, and because otherwise the numeral words, pronouns, and other words in which they occur could not have been properly dealt with; see the numerals 1, 5, and 10, and the pronouns, and the other words given, which have one of these gutturals as their first letter. Thus we can see the reason for, or have the key to the phonology of such forms of the first syllable or letter in the word for 10, as we have in *garula*, *chăbulu*, *ahuru*, &c.; for 5, as in *tima*, *rima*, *hima*, *kima*, *ima*, &c.; for 1, as in *taday*, *tasi*, *tai*, *rari*, *tas* or *rais*, *ray*, *aida*, *aisa*, *asa*, *ida*, *isa*, &c.; for I, *as in haku*, *laku*, *daku* or *aku*, *zaho* or *aho*, *hanu*, *kinau*, &c.; for We, as in *hana* (*-m*), *kina* (*-mi*), *kin* (*-ta*), *ka* (*-mi*), *ki* (*-ta*), *zaha* (*-y*), *si* (*ka*), &c.; for Thou, as in *hica*, *daka*, or *ang*, *ik*, &c.; for You, as in *dakau* or *angkau* or *kangkau*, *sicamo*, *hicamo*, *akam*, &c.; and for who, which, as in *he*, *sei*, *fei*, *me*, *vai*, *ba*, *hai*, *rai*, *wai*, *ai*, *hei*, *tei*, *thei*, *za*, &c.

Nothing has been said in this paper of the race varieties and geographical distribution of the Oceanic speakers, as the linguistic question must be considered on the principles of linguistic science, independently of discussions on those points, important as they are; and the settlement of the linguistic problem will give the greatest aid to the settlement of these, and must be settled before the discussion as to these can attain to any certainty.

No. 16.—SOME ANTHROPOGRAPHIC NOTES ON THE TANNESE, NEW HEBRIDES.

By Rev. W. Gray.

(*Read Tuesday, January* 11, 1898.)

Recommended to be forwarded to the Anthrop. Inst., Lond., and accepted by the same.

No. 17.—PROPOSAL FOR AN ETHNOLOGICAL BUREAU FOR THE ADVANCEMENT OF THE STUDY OF THE ETHNOLOGY OF THE PACIFIC.

By A. Hamilton, Dunedin, New Zealand.

(*Read Tuesday, January* 11, 1898.)

For the more convenient and thorough study of the ethnology of the Pacific, it is, I believe, desirable that this Association should take into consideration the advisability of establishing a Bureau of Ethnology for the special purpose of applying modern methods of scientific investigation to the due record of the races of the Pacific area. On all sides it is admitted that much has been lost that would have been of priceless value, and that many islands have been so affected by civilisation that it is hopeless to try to recover the traditions or customs of the original inhabitants. The demands of trade are, to a large extent, responsible for this derangement of the primitive culture. Private collectors and private enterprise in the islands are apt to do more harm than good unless controlled by scientific direction. Specimens collected have been largely selected for their showy or unique character, quite regardless of their ethnologic value. Thus it is with a view to a general control over the somewhat haphazard way in which our knowledge is being acquired that I suggest a central bureau. I may say at once that I do not propose to interfere with any existing institution or society, but only to aid and organise research on lines that will ensure the best results.

Let us first see what has been done and how to utilise what has been done to the best advantage.

Then what should be done, and how to do it. There are a host of observations made by voyagers from Cook downwards, by missionaries, traders, scientific travellers, and local residents in various parts of Polynesia. They are scattered up and down in thousands of pages of books of all sorts and sizes, and all degrees of dulness and dryness. To attempt to follow out a special subject demands access to a special library and a thorough preliminary knowledge of what to look for and where to find it. The observations of ethnological facts are recorded—

(*a*) In book-form (separate publications).
(*b*) In the transactions of learned societies.
(*c*) In unpublished manuscripts in public and private collections.

In the books you may get perhaps half a dozen interesting facts and 300 pages of padding—very pleasant reading perhaps, but not satisfying.

These records require to be brought together, and the facts contained in them extracted and arranged under various headings for reference.

A very suitable method is to be found in the card catalogue system so much used in libraries. Each fact should be transcribed on a separate card, having a suitable catch-word, and the precise reference for the extract.

These cards should be arranged under various heads or subjects, so that the whole of the information available on any subject could be brought together and subsequently collated and edited.

Proper provision would be required for the custody of the original cards or slips at a central or main bureau.

Typewritten or printed copies of any card, or series of cards, to be supplied, on payment of the cost of transcription, to all applicants.

Published illustrations belonging to the literature of the subject should also be collected and a separate descriptive card or slip catalogue prepared. In many cases it would be an advantage to reproduce good figures on a uniform scale by photographs, and to supply them at a reasonable rate.

Language of the record. Extracts for the cards should be in the language of the original; but provision should be made for the translation of any works not available in either English or French.

To render the analysis of the material then brought together of the highest value, copies of the slips or cards should be supplied, under the direction of a committee, to those specially qualified to judge as to the accuracy of the information recorded. These persons should write their opinions or views of the matter in question on the card, in spaces provided for the purpose, sign it, and either forward it to the next person on the list or return it to the central bureau. The question of a library for the bureau, of all works on Polynesia, is of great importance; but for the present I should suggest that loan of the books required for the card abstract might be obtained from the numerous special collections—as I am satisfied that the large sum of money that would be required to purchase anything like a complete library would be better expended in other directions. And this brings me to what I may call aggressive work.

1. Circulars carefully drawn up asking for specific information should be issued as widely as possible, carefully followed up by correspondence, and the information contained in the circulars returned to the bureau passed into the general card record.

2. By obtaining photographs of anthropological and ethnological subjects by purchase, by gift, or by exchange. Similar directions to be issued as to the mode in which it is desired such photographs should be taken. If practicable, to supply photographic prints, or copies of material thus recorded, in the same way as copies of cards, at cost price.

3. By supplying printed directions or forms for observers in outlying islands, and in special cases furnishing apparatus.

4. Organising or assisting explorations of areas little known or remote from ordinary trade routes.

5. Obtaining classified lists of the ethnological specimens from the Polynesian area now in museums, with copies of the labels. These lists to have references to the photos when articles are represented photographically in the general collection.

As a way of carrying out the suggestions here given, I think that the Association should take steps to place the matter before the learned societies of each county or colony having territorial claims in the Pacific, and having drawn up a scheme, arranged the details of operations, and ascertained the probable expenditure required, representations should be made to the various Governments pointing out the necessity for immediate and concerted action and asking for their co-operation and assistance, financial and otherwise. The Governments might be asked to nominate representative members of the General Committee, whose services might be of value in defining the areas of survey and giving the Governments a voice in the expenditure of any grant made by them. It is essential that great care be given to the general plan of operations so as to avoid duplication or overlapping of work. The first steps, then, would be to get a Special Committee of the Australasian Association for the Advancement of Science appointed to draw up a report on the proposal to establish an ethnological bureau for the advancement of the study of the ethnology of the Pacific. The committee to consist of representative members from each of the Australasian colonies, with power to add to their number.

If possible, a preliminary report should be presented before the close of this session of the Association.

Two questions immediately arise which would have to be dealt with by such a committee—

1st. The locality of the bureau.

2nd. The funds wherewith to carry out the works proposed.

I think the first of these should depend largely on the financial aid given and the convenience of the locality for the work. I have, however, no doubt that this could be arranged.

The second question—funds—is more vital. I suggest the following as sources from which funds might reasonably be expected :—

1. Annual grants from Governments co-operating.
2. Annual grant from Australasian Association funds.
3. Votes from learned societies for special purposes.
4. Donations from individuals for general or special purposes.

This scheme does not propose to interfere with any existing institution, but only to aid and organise research into the ethnology of the Pacific.

No. 18.—OLD SAMOAN AMUSEMENTS.

By Rev. J. B. Stair.

(*Read Tuesday, January 11, 1898.*)

No. 19.—AUSTRALIAN CAVE PAINTINGS AND ROCK CARVINGS, WITH SUPPOSED TRACES OF POLYNESIAN ART.

By Rev. J. B. Stair.

(*Read Tuesday, January 11, 1898.*)

No. 20.—ALPHABETIC OR SYLLABIC CHARACTERS IN CAVES ON THE GLENELG RIVER, N.W. AUSTRALIA.

By Rev. John Campbell, LL.D., Professor of Church History, Montreal.

(*Read Tuesday, January 11, 1898.*)

The characters of the brief inscription you have sent me a copy of are easily recognisable as those of the ancient Turunian syllabary employed by the ancestors of the Japanese and kindred peoples, of which inscriptions are found in Siberia and Japan, and of which the Corean alphabet is the lineal descendant. The Buddhist syllabary of India and the south-east of Asia has the same origin, but is of a different type; so that I have but little hesitation in calling the Australian inscription ancient Japanese—as ancient, perhaps, as the tenth or eleventh century, for in 1125 A.D., as the Khitan, the Japanese were expelled from China, and doubtless carried with them their modified Chinese characters now in use, which superseded the old syllabary to such an extent that the Japanese cannot read their old inscriptions. In the Survey of the Northern and Western Coasts of Australia, by Captain Flinders, R.N., Hist. Records of N.S. Wales, p. 78, is an account of Malay visits to its coast for the trepang fishery, but I know of no authority for a Japanese expedition to it. In the light of many inscriptions read by me, I transliterate as follows :—

ki	o	chi	o	sa	chi
or	or	or			or
gi	u	shi			shi

Put into words these read :—

kiochi	osa	shi
hopeless	number	is

Osa governs *kiochi* in the genitive by position; hence we read, "The number of the hopeless (ones) is." Here we have the meaning of the dots in the right hand, which are no doubt units, 21, 24, 17, in all 62, perhaps purposely put in three unequal lines to mark a triple distinction of rank, vessel, habitation, or subordinate local origin.

Note.—The inscription referred to will be found on Plate IX, A.A.A.S. Reports, Vol. vi, Brisbane Session, 1895.

It is plain that sixty-two Japanese were cast ashore on the west coast, somewhere near the place in which the inscription is found; that their junk or junks were so totally destroyed as to render the castaways *hopeless* of return; and that they must have found sufficient means of subsistence to enable them to live some time—long enough at least to complete this task. Their landfall can hardly have been later than the beginning of the 12th century, because there is every reason to believe that at that time the old characters were superseded by the present modified Chinese.

I have no representation at hand of Japanese idols, or of ancient conventional representation of the clothed human form, but perhaps you can find such, and compare with the figure of the inscription.

What became of the sixty-two castaways? Is there in Western Australia any tradition of an ancient tribe of foreigners and of their massacre, or is there any trace of their amalgamation. They must have brought with them copper tools and other implements and ornaments. Is there any trace of them beyond this carving? I need not say that ethnologically there is no near relationship of the Japanese and the Melanesian, so that the native origin of the document is out of the question.

Inscriptions in the same character and language are found in this continent, as you will see by the accompanying paper by me. The ancestors of those who wrote them were driven to the American coast by the elements, having been, in all likelihood, banished from home to the mercy of the ocean. The sixty-two of your inscription may also have been banished political offenders, rather than trepang fishers or traders; but who can tell?

No. 21.—SOME INDIAN WORDS OF RELATIONSHIP USED BY THE AUSTRALIAN TRIBES.

By JOHN FRASER, B.A., LL.D.

(*Read Wednesday, January 12, 1898.*)

No. 22.—NOTES ON THE ROCK CARVINGS OF AUSTRALIAN ABORIGINES IN THE WOLLOMBI DISTRICT, N.S. WALES.

By W. J. Enright.

(*Read Wednesday, January 12, 1898.*)

No. 23.—VOCABULARIES OF THE GEELONG AND COLAC TRIBES, COLLECTED IN 1840.

By John J. Cary.

(*Read Wednesday, January 12, 1898.*)

The slight knowledge of the Australian language given to the world has been mainly the work of Christian propagandists. With his grammar of the Lake Macquarie dialect, published at Sydney in 1827, L. E. Threlkeld may be said to have led the way. Others, like Gunther, Teichelmann-Shurmann, Taplin, and Ridley, have followed with copious vocabulary, phrase-book, or grammar; while to-day the material for similar contributions to linguistic science is no doubt still being gathered by zealous missionaries—for example, the Jesuits in the Northern Territory, or the Benedictines of New Norcia, near the capital of the Golden West; and from the manuscript of an early missionary is drawn the interesting peculiarity now under notice.

In 1838 the Wesleyan Methodists commenced an aboriginal mission at Port Phillip; they established the Buntingdale Station at the source of the Barwon, and tried, unsuccessfully, to reclaim the Wod-dow-ro, Dantgurt, and Kolijon tribes. One of the missionaries first sent from England to carry on the work was Francis Tuckfield, a young Cornishman, brave and hopeful, who entered on his new life with the zeal of an enthusiast. Naturally, chilling experience somewhat lessened this ardour; but when State aid

was withdrawn, and private support grew lukewarm, and when hope of success died within him, a strong sense of duty kept him at his post, and not until the Government resumed possession of the Buntingdale acres, and marked them out for public selection, did he abandon the mission. Ten of the best years of his life were spent trying to Christianise and civilise the above-mentioned tribes.

Having an aptitude for language, he soon learned the native dialects, but of his writings on the subject only a part remains. A large vocabulary was compiled in the first years of the mission, but it was unfortunately lost in a fire that destroyed the mission-house. Tuckfield himself, forced to leap out of a window, narrowly escaped with his life. His journal and copies of private letters contain a few brief remarks on the aboriginal language; but in his note-book is preserved a collection of about two hundred short sentences, some translations of Scripture, and a vocabulary of over two hundred words. By the kindness of the Tuckfield family, it has been my privilege to inspect their father's journal, letters, and note-book; and when perusing the latter I unearthed a grammatical form of number hitherto practically unnoticed as a peculiarity in Australian language. That dual number is a feature of several Australian dialects is well known; but with the Wod-dow-ro, number as a means of precision was amplified yet another degree. And herein lies the discovery: these natives of the Geelong district used triple number. Although "it is not rare to find among uncivilised peoples a linguistic faculty superior to that of their neighbours or of their civilised kindred," yet it is remarkable to find among these savages such an apparent sign of mental activity. Triple number is not found in the language of the Dravidians, who are regarded by some writers as the progenitors of the Australian race. We may therefore conclude, admitting that we must look for "the ancestors of the Australians in Hindostan," that the Australian invented triple number himself, or else he preserved a form of speech that was lost centuries ago by his Indian congener. As to its use in Australia, it is difficult to believe that it was spoken only by the Wod-dow-ro, who in customs and daily life were typical natives: death-dealing superstition stalked among them; polygamy, infanticide, and cannibalism prevailed; tillage was unknown; and, furthermore, in the speech of the three tribes, indications could be found pointing to original unity with the dialects of remote tribesmen. Using Threlkeld's and Teichelmann's grammars, Francis Tuckfield compared the dialects spoken in the vicinity of Buntingdale and others of Victoria with those of New South Wales and South Australia; and this was his conclusion: "In construction and character they are radically and grammatically the same." Referring to the language of the three

tribes, Tuckfield says: "It appears to me to be copious, very significant, combining great power with simplicity, and for the most part its sounds are pleasing to the ear. . . . Although it has many pecularities, especially in the use and number of the pronouns, some of these pecularities add to its precision and perspicuity. I will mention one or two as a specimen. 'You go' in English may signify one, two, three, or more. This language furnishes a different word in the three senses without using the numeral adjective."

This wealth is shown by the following list, which is the best illustration extant of the use of triple number:—

PERSONAL PRONOUNS.

Nominative Case.		*Possessive Case.*	
Singular.		**Singular.**	
Bangik,	I.	Bang-ong-ik,	My, mine.
Bangen,	Thou.	Bang-go-de-gnen,	Thy, thine.
Bang-nuk,	He.	Bang-go-de-duk,	His.
Dual.		**Dual.**	
Bangul,	We.	Bang-go-de-ul,	Ours.
Bangbullok,	You.	Bang-go-de-bul-ok,	Yours.
Bang-a-bul-ong,	They.	Bang-go-de-bul-ok,	Theirs.
Triple.		**Triple.**	
Bang-etuk-kol-lik,	We.	Bang-ong-etuk-kol-lik,	Ours.
Bang-ud-kol-lik,	You.	Bang-ong-ud-kol-lik,	Yours.
Bang-tan-a-kol-lik,	They.	Bang-a-tan-a-kol-lik,	Theirs.
Plural.		**Plural.**	
Bang-wod-jok,	We.	Bang-a-wod-jok,	Ours.
Bang-ud,	You.	Bang-ong-ud,	Yours.
Bang-tan-ong,	They.	Bang-go-de-tan-ok,	Theirs.

[Not strictly as classified by Tuckfield; arranged as above for convenience.]

Not a few of these pronouns are cumbrous looking, but it seems they were not always spoken thus. The native clipped his words, and sentences* such as Ka-ar-*dik*—I talk; Willong-*bul*-bon bore—When will you cease to run about (dual)?—and Winyer kod *kol-ik-ka*,—What are you talking about (triple)?—show that in ungis

* The sentences are from Tuckfield's Note-book, which also gives a few more examples of triple number: Kel-ter-a-len tanong kollik—three talking; Pe-del-wa-wa den—Strike us three; Pe-del-a gnel-en-tanong—Strike us three; Gnerd en bop mo *gnul-en* long gong ga boy jo detable mur-un-nuk—The Great Spirit loves us (three) who have a crying heart.—J. J. C.

the three numbers he was able to speak with brevity as well as precision. The syllabification of the first sentence is according to Tuckfield's entry; *ik* is a contraction of *bangik*, and the presence of *d* in the last syllable may be accepted as an example of the fusion of words by the natives, *comme le Français faire la liaison.*

The use of *ka-ard* in the first and *kod* in the third sentence no doubt indicates the inflection of verbs for number. That the above forms of number once existed in widely separated districts of Australia seems indeed highly probable. A strong affinity is found in the singular dual and particular duals of eastern dialects, and in this connection one may mention the use of pronouns in common by such tribes: thus *winyer*, what, of the Geelong district, is *winyar* at Lake Hindmarsh (Vic.), *minya* at the Brisbane River (Queensland), and *minya* on the Liverpool Plains (N.S.W.); *bangik*, I, becomes *bangeek*, *bangak*, *bangak*, *bangak* in four dialects* of north-west Victoria, and *bang* in the Lake Macquarie district (N.S.W.); but it may be safe to affirm that, like the Geelong and Colac natives, one south-eastern tribe retained the third number. What certainly seems to be an example—*naiowing*, we three—is found in the language of the Twofold Bay †aboriginies.

Was triple number once commonly spoken by the Australians? Is it a relic of their ancient progenitors, or must we seek its origin on this continent? These questions may now be left to conjecture, and in the absence of aboriginal literature or writing, perhaps it may not be too bold to say that it is doubtful if conclusive answers to them will be found even in the comparative study of the Australian family of languages—a field of research still awaiting the scientific investigator.

My thanks are due to the Professor of Philology of the Melbourne University for kindly considering the foregoing, and who writes as follows:—

"I have carefully considered your paper; but as I am not personally acquainted with the Australian tongues, I do not feel any right to express an opinion upon the special functions illustrated therein.

"The pity is that more example is not supplied, and that some authority beyond Tuckfield's is not forthcoming. Even if we assume that the triple number is really expressed, there remain the questions—(1) Whether the elements expressing that notion are really affixed or merely juxtaposed? (2) Whether the said elements have any independent existence as words in any sense whatever?

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* Eyre's *Journals of Discovery*, vol. ii, p. 401.

† Rev. W. Ridley's *Languages of the Aborigines of Australia*, p. 115: (Sydney, 1875.)—

I,	Naiadha.	I and thou,	Naiawung.
Thou,	Indiga.	We three,	Naiowing.

"It is noticeable, for example, that in *all* the triple persons the attached elements, *kollik*, appear; while in the singular and dual there is no such agreement of ending. Is there any way of discovering an independent *kol* (*lik*) in an appreciable sense of its own? Or is it always and only pronominal?

"If in English we say 'We do,' 'We-two-do,' 'We-three-do,' the step to agglutination is but a small one. Did the Australian simply do the same and stop at 'three,' because it had no further numerals?

"Thus you give the dual as containing *bul*; but *bul* is the ordinary Australian for two, or at least is contained in the word for two.

"Similarly I find that *kuliba* and *guliba* are Australian for three, and I should say that *kol*(*lik*) is an appearance of three in your compounds."

As regards answering Professor Tucker's question—Whether the elements expressing triple number are really affixed or merely juxtaposed?—Tuckfield's MS. furnishes no helpful assistance. The answer must, therefore, be drawn from the pronouns themselves. But if we inspect the six examples of triple pronouns, we will find that the said elements appear to be infixes, placed between the two syllables of the word *bangik*. For example, insert *etuk koll* between the two parts of the word, and we have bang-etuk-kol-lik—we; prefix *ong* to etuk-koll, and by the same process we get bang-ong-etuk-koll-ik—ours. Interposing *ud* koll gives bang-ud-kollik—you; prefixing *ong* to ud-koll makes bang-ong-ud-kol-lik—yours. Incorporating *tan-a-koll* forms bang-tan-a-kol-lik—they; and prefixing *a* to tan-a-koll gives bang a tan a kol lik—theirs.

As a similar formation also occurs in five examples of the possessive cases, singular and dual, and also in the plural, it seems quite safe to conclude that in the pronouns of triple number "the elements expressing that notion" are neither affixed nor juxtaposed, but incorporated.*

Passing to the second question, we may reasonably confine our attention to *kol*. The same combination of letters forms the first syllable in the names of seven birds—koling-ar, parrot; kol-ka-wil, predatory bird, &c.; but Tuckfield furnishes no Wod-dow-ro, Dantgurt, or Kolijon word showing *kol* used as a numeral. As a matter of fact, it could not occur in Wod-dow-ro, Dantgurt, or Kolijon as the root syllable of three—none of these dialects had such a numeral; in each, three was expressed by two and one.

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* "Words are formed by means of *suffixes* alone, the formative element being placed always at the end of the word."—Abel Hovelacque, Science of Language; *Australian Languages*, p. 68.

Thus finding triple form expressed by a word not known to the speakers as a numeral, does not its presence indicate what may be termed the survival of a grammatical form of precision?

The supposition regarding triple pronouns as the conjoining of the numerical syllable to roots expressive of pronominal relationship seems to be thus fairly set aside. But turn to the dual form, and what do we find? Here we clearly see that, in the three dialects, *bul*, " is contained in the word for two."* In Wod-dow-ro, bulad, two, is traceable in Buk-ar-bul-ok—the residence of the late Captain Fyans—signifying between two waters; and in dajorongbullok, the eldest of two sisters. This second example, which seems quite akin to the dual pronoun *bangbullok*, is found among names of family relationship, recorded by Tuckfield; and the following derivation of both examples is drawn by me from his MS.:—Bukarbullok-*bokariu*, middle; *bulad*, two; *yallok*, water; dajorongbullok-*dajorong*, implying priority of birth; *bulad*, two; *worok*, denoting female.

Now, although the termination *ok* in the dual pronouns remains unexplained, it must be admitted that the element *bul* in those compounds, in bukar*bul*lok, dajorong*bul*ok and *bul*ad may with good reason be considered as the same identical root syllable.

But granting that, may we not reasonably ask what evidence is there showing *bul* to be a veritable numeral? May it not first have been applied to some right, act, or powers of two individuals, and then by a natural transition of meaning, like our couple or brace, have acquired an exact numerical significance?

Benjeroo, two, is shown by Bunce to also mean couple, brace, and *two wives*.

It seems, indeed, as feasible to suppose that the dual form supplied the Wod-dow-ro with the numeral adjective, as to suppose that they allowed the word for three to drop out of use as a numeral, and yet retained its root syllable in pronominal usage. If the word fell into disuse on the death of a native in whose name it occurred, it would have wholly disappeared†; a personal application of such a term would be the least likely to survive.

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* Tuckfield's MS. contains no numerals. The following are from Eyre's "*Journals of Discovery*," vol. ii, p. 400:—

Two and two—

W. Bul-ad-barp-bul-ad.
D. Bul-ad-da-bul-da-da.
K. Bul-ad-duk-bul-ad-duk.

† "The Australians believe that a dead man's ghost creeps into the liver of the impious wretch who has dared to utter his name."—Clodd's *Myths and Dreams*.

SUMMARY OF PAPER ON WOD-DOW-RO, DANTGURT, AND KOLIJON.

Title. Other Authorities. Prefatory Note.

Letters. Sounds. Change in Words.

Classification. The Noun.

Inflection of the Noun.

Derivation of the Noun.

Pronouns.

Interjection. Unclassified Word. Emphasis.

Example of Parsing. Examples of Syntax.

VOCABULARY.

Names of Natural Objects:—The Seasons. Parts of the Body. Quadrupeds. Birds. Reptiles. Fish. Insects. Trees and Shrubs.

Words *b* to *y*.

Sentences and Phrases.

Scriptural Paraphrases:—The Fall. The Commandments. The Lord's Prayer. Homily, A Fragment. Grace before and Grace after Meals.

Appendix.

AUSTRALIAN LANGUAGE: WOD-DOW-RO, DANTGURT, AND KOLIJON.

THE dialects spoken by the Aborigines of the Geelong and Colac districts. From the MSS. of Francis Tuckfield, Collated by John J. Cary.

Wod-dow-ro, Dangurt, and Kolijon words not included in this collection are found in—

R. Brough Smythe's "Aborigines of Victoria," vol. ii.

John Hilder Wedge's "Note Book"; Bonwick's "Port Phillip Settlement," p. 247

G. T. Lloyd's "Thirty-three Years in Tasmania and Victoria," p. 470.

E. J. Eyre's "Journals of Discovery," vol. ii, p. 400–2.

The Witouro list of words found herein, and incorporated also in "The Aborigines of Victoria," was very probably obtained originally by Edward Stone Parker, Assistant Protector of Port Phillip Aborigines, who refers to Witouro as one of eight dialects used in his district. "Papers Relating to the Aboriginies" printed by order of the House of Commons, 1844.

Samuel Mossman, whose short list of Wod-dow-ro words forms an appendix to this paper, was an early resident of Port Phillip, coming to Geelong in 1841. He has preserved a few crumbs of information concerning these times in a small *brochure* or two, besides leaving some MS. notes.

PREFATORY NOTE.

Wod-dow-ro, Dantgurt, or Kolijon denotes both the language and the tribe.

The meaning of Wod-do has not been ascertained, but *wro* (lips) figuratively means speech or language; and as East Australians frequently named themselves after their language, most probably so did the aborigines, who naturally spoke Wod-dow.

But Dantgurt-kuddet and Kolijon-gnundet seem to be the completed forms of the second and third name, the suffixed word in each instance signifying either tribe or language.

Wod-dow-ro is F. Tuckfield's form of the word, as obtained from the aborigines who once occupied the Geelong district. Watorrong, Witowurong, Witowro, Witouro and Woddowrong are variants.

Witouro is given as the dialect of the aborigines of the Ballarat district who roamed in the vicinity of Buninyong and Lake Burrumbeet. Comparing it with the Wod-dow-ro now available, shows, however, that the Geelong and Ballarat aborigines spoke the one language, and, no doubt, they were but different sections of the same tribe.

The Wod-dow-ro was a good type of the Australian coast dwellers, but we can only conjecture as to whether the tribe was numerous or not. The Geelong sections—Corio and Barabil—are variously estimated by early settlers as consisting of 170 or 300 souls.

The hunting ground of the Wod-dow-ro was extensive, well watered, and, from all accounts, generally furnished an abundance of game. Broadly speaking, it included the whole of the present county of Grant and part of Grenville on the north.

The Kolijon is spoken of as a small tribe roaming in the vicinity of Lakes Colac and Corangamite.

The Dantgurt was only a section of a tribe named Manmait, whose hunting ground touched the western boundary of the Kolijon. With the advent of the whites, the sectional name seems to have supplanted the tribal.

LETTERS.

Nineteen letters are used in writing these dialects—a, b, d, e, g, h, i, j, k, l, m, n, o, p, r, t, u, w, y. The natives were unable to pronounce f, c, h, s, x, and z. Many of them could not distinguish between the labials b and p, nor the palatals d and t.

Obs. Tuckfield uses h in the aboriginal in one or two instances only. He says but sixteen letters were necessary to form an aboriginal alphabet.

SOUNDS.

A set of marked vowels, by Tuckfield, shows *a* with one long and one short sound, as in fär and fat* ; *e*, as in mē and end ; *i*, as in bit ; and *o*, as in nō, not, and möve ; *u*, as in būll, and as in tub ; tär, gnan ; pēdong, dilbel ; kar-i-gnal ; bō, kol, lök ; bū ad, kumbe.

The sounds of the dialects were, for the most part, pleasing to the ear.

A nasal sound, common to the Australian, is represented by the letters *gn*. It is produced by placing the organs of speech in the position required to pronounce *g* hard. The sound is then emitted through the nose, like the letter *n*. This sound gave the Europeans much trouble.

Gn changes to *k* in neighbouring dialects, and the initial corresponds with *k* in different sections of the same tribe :—Gnenong (Wod.), kenong (Kol.), foot ; gnurdong (Wod.), knardon (Wit.), mother ; gnarn (Kol.), karl (Dant.), dog ; gnundet (Kol.), kuddet (Dant.), tribe or language ; gnun-ye, kuren-ye, small.

The following list of words in Wod-dow-ro and Witowro† will help to show the mutability of speech among two sections of the same tribe, establishing at the same time their identity :—

Natural Objects.

Wod-dow-ro.	Witowro.	English.
Da	Dar	Earth
Gnubet	Moabet	Water
La	Lar	Stone
Tot-ba-ram	Toort-baram	Stars
Mondar	Mundar	Rain
Mondar	Mundar	Thunder
Morgal	Moorkalyn	Night
Mere	Mirriyu	Day (or Sun ?)
Weng	Wing	Fire
Wor-a-wor	Woorer-woorer	Sky

Animals and Birds.

Karwer	Kowe	Emu
Koim	Goim	Kangaroo
Karl	Garl	Dog
Wollard	Wollert	Opossum

Parts of the Body.

Genong-etuk‡	Tinnan	Foot
Gnern-der	Nar-een-gan dan yook	Beard
Karem	Karreem nook	Thigh

* Tuckfield's form of the numeral two, bul-laid, shows *a* as in fate.
† Eyre's *Journals of Discovery*, vol. *ii*, p. 401–2.
‡ Etuk is suffixed to all Wod-dow-ro names of parts of the body.

Kaung	Karn	Nose
Liangeduck	Leanyook	Teeth
Mirgnetuk	Mirrook	Eyes
Morrok	Moorn yook	Head
Morom	Murrum knook	Soul or spirit
Murna	Munangin	Hand
Tellang	Tallan	Tongue
Woroo-worung	Wooru-tan yook	Lips, mouth, speech

Family Relationship.

Amerjig	Amygeet	White man
Bagorok	Bagorook	Woman (black)
Gnurdong	Knardon knettuk	Mother
Kuly	Gole	Man
Mondegorok	Mondegorook	Old woman
Pedong-etuk	Pedouring ettuk	Father
Wor-dong	War noong	Brother

Weapons.

Karp	Karp	Spear
Gare	Tark	Spear (hunting)
Leangwell	Leangil	Waddy with curved end
Wongern	Wangim	Boomerang

Common Terms.

Borok	Borack	No
Dedawon*	Detarwat†	* I shall die, †Dead?
Karung	Karrong	House
Mognet	Mongak	To make
Mort	Moert	Short
Nerim	Nerim	Long
Newlem	Noolam	Bad
Kunubenuk	Koenebanyook	Good
Winyar	Wear	Where
Eramu	Yeramun	To-morrow

PARTS OF SPEECH.

The words of the Wod-dow-ro, Dantgurt, and Kolijon dialects may be classed as nouns, pronouns, adjectives, verbs, adverbs, conjunctions, and interjections.

A few remarks of interest will here be made concerning the noun and pronoun.

THE NOUN.

The common noun is either—(1) Simple—as bon, knee; da, earth; la, stone; (2) collective—as kin-kin-bil (Wod.), mar (Dant.), mandel (Kol.), people; nanok nanworen, fur tribe; or (3) abstract—as deraba, shame; konda, sorrow; morom, a spirit.

Examples of nouns of the second and third class are few.

GENDER.

Inflection.—As regards gender, F. Tuckfield shows that *worik* is a feminine suffix: Kurenyemer*worik*, "She-with-the-small-eyes." *Worok*, *gorok*, and *goruk* are variants of the word. No mention is made of a masculine suffix; and the feminine can be traced in the names of persons only.

From the subjoined table it will be seen that gender in nouns was more commonly expressed by different words:—

Wod-dow-ro.

Masculine.	Feminine.
Amerjig. White man	Amerjigorok. White woman
Kuly. Man.	Bagoruk. Woman
Pedong. Father	Gnurdong. Mother
Wordong. Brother	Bermborok. Sister
Wagnakik. My younger brother	Bermboragik. My younger sister
Dedeik. My youngest brother	Dajerik. My eldest sister
	Dajorongbullok. Eldest sister of two
Mommomik. My son	Wong-gongik. My daughter
Tanddopek. My uncle	Male koragik. My aunt.

Dantgurt.

Amerdeit. White man	Amerdeitair. White woman
	Tamtambora. Woman
Be-bi. Father	Gner-rong-gi. Mother
Wordi. Brother	Ko-ker. Sister
Ko-ko-gnun. My younger brother	Towelja. Aunt
Gnum-i. My uncle	Ka-ki. My elder sister

Kolijon.

Amerdeit. White man	Amerdeitgoruk. White woman
Tharong. Man	Nodnoat. Woman
Ma-ma. Father	Ba-ba. Mother
Derda. Brother	Banget. Sister
Koromboit. My younger brother	
Ka-gnet. My uncle	Malankaugnek. My aunt
	Dattonget. My eldest sister

It may be noted that *wererup* a common term for the "sorcerer" of a tribe, can have no feminine, women never filling that office.

Lapmolong, widower, and *pondak*, widow, no doubt belong to one of the three dialects; but Mr. Tuckfield has merely listed them in his general vocabulary.

NUMBER.

He gives only one example of the change of a noun singular to plural, viz., mir, eye; mera, eyes.[1]

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* See example of parsing.

CASE.

The vowels *a*, *iu*, and *u*, when suffixed to nouns, appear to serve as case endings. For example, murna, hand ; murna*a*, in (the) hand ; weing, fire ; weing*iu*, to (the) fire ; Sunday*u*, of Sunday.*

DERIVATION OF NOUNS.

A few examples of derivative and compound nouns that have been traced by the aid of F. Tuckfield's vocabulary give an interesting glimpse of aboriginal word-formation.

Derivatives appear to be formed by the aid of the suffix *abil* or *bil*, which signifies one of, or pertaining to ; thus—

Tarekabil, signifies an erect person—one straight as a spear—tare, a spear ; k perhaps euphonic ; and abil pertaining to. (Wod-dow-ro.)

Taregil is the Kolijon form of the word.

Yanabil, a visitor, may perhaps be closely rendered as one of the comers, or one of the goers—yan expressing motion to a place, as in yan-gal-e-nut, to walk ; yan-garamela, to come back ; and yanik, I go.

Nanworabil denotes a bear, opossum, or any furred animal ; while

Karignalabil, Creator ; gnariwel, an adult ;

Kin-kin-bil, people ; and

Nilarngwarabil, the finny tribe, are also examples.

Abil was thus attached to a simple noun or verb, or to a compound word.

Gunong, or a contraction of it, seems to aid as a suffix in forming :—

Pedong, father	Myungunong, liar
Wardong, brother	Dilokongong, fighter
Gnurdong, mother	Bilmgonong, thief.
Lapmolong, widower	

Compound nouns consist of—(1) A noun preceded by a noun, as Korong*wrong*, frog-*face* ; Mulga*mom*, shield-*point*. (2) A noun preceded by an adjective, as Nerim*genong*, long-*foot*, Newlem-*boit*, bad *heart*. (3) A noun preceded by a verb, as Pone*melang*, bite-rat—*i.e.*, "an eater of rats."

These and similar compounds were the nicknames of individuals, it being customary for the aborigines to name their children after some particular circumstance occurring at the time of birth, or after the food they eat, or a personal peculiarity.

To the names of the females the sign of the feminine gender was also tacked on—Korinemurnongorok, korine, bitter ; murnong, an edible plant ; gorok, female.

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* Sentences and Phrases—15, 18, 60–1, 94, 138, 147, 152, 172, 196 ; Homily—6, 9, 12, 13, 14. The Fall—22, 25.

This name was given to her as she was born in a place where, and at a season of the year when, the murnong was bitter.

In all such compounds listed, the qualifying word is invariably placed first.

Compounds also consist of an agglomeration of several words having syllable elided, as—

Dajorongbullok, "the eldest of two sisters"—dajorong, implying priority of birth; bul, a contraction of bulad, two; and ok, a contraction of worok, female.

Bukarbullok, is also formed of at least three abridged words, two having the end, and one the beginning cut off; bukariu, middle; bulad, two; and yallok, water. Bukarbullok, "Between two waters," designates a corner of Marnock Vale, Geelong,* around which the Barwon sweeps in a horseshoe curve.

Tarigemiretuk, eyelash—spears or reeds of the eye—comes by a similar agglutinating process—tare, spear or tark reed; i (?); ge, of the; mirgnetuk, eye.†

Compounds with complete words juxtaposed, as Korongwrong, &c., are no doubt more newly coined than those with elisions, the latter class having their edges, so to speak, rubbed off after long usage; and no doubt the components of many of these will never be traced.

PRONOUNS.

Pronouns may be classified as personal and interrogative.

"Personal pronouns that stand alone, or that are used in answer to an interrogative of personal agency, are different from those that are used in connection with verbs, or in answer to a question of the act, *e.g.*, in answer to the question of personal agency, "Who speaks?" (Wela karing?) the answer would be, "Karing bangik," (Speak I.) In answer to a question of the act, "What are you doing?" the answer would be "Kudgellengik," (Eating I.) In this sentence *ik* seems to be a contraction of the personal pronoun, *bangik;* but in other interrogatives, we have other pronouns depending, it would seem, on the consonant with which the verb terminates. Hence it seems to us at present that there is an endless variety of pronouns in the language."‡

* Similar contractions are found in the names of places in the Colac district. Lake Corangamite—Bitter water; korine, bitter; gnubet, water. Lake Burrumbete—Round water; burum, round (?); gnubet, water. Wurdibulok—wurdi, large (?); bulad, two; yallok, water.

† *Ge* in this example, in the Wod-dow-ro, Mur*ge*bulok, the brightness (?) of two waters—a spot at the junction of the rivers Leigh and Barwon—and in Tarntarni*ge*lok, the good snaring water, may be a contraction of *gewa*, there. Some of the words given as derivatives are probably compounds.

‡ F. Tuckfield's Journal. Draft of "*Report to the Rev. Secretary, Wesleyan Mission House, Hatton Garden, London.*" *June* 31, 1840. The quotation regarding trinal number given in my paper *A Discovery in the Australian Language*, is also from the above-mentioned draft.

The following list of compounds served as personal pronouns in the three dialects :—

PERSONAL PRONOUNS.

A Comparative View.

Wod-dow-ro.	Lant-gurt.	Kolijon.	English.
Bang-ik	Gnud-duk	Gnud-do-it	I
Bang-ong-ik			Mine.
Bang-ul	Gnud-do-a-al	Gnud-dol-a	We two.
Bang-go-de-gnul	Gnud-do-un-a-u	Gnud-dong-ul-a	Of us two.
Bang-ul-len			Us two.
Bang-etuk-kol-lik	Gnud do gnan-nen	Gnud do gnen nuk	We three.
Bang-wod-jok	Gnud-do-gnan-nen	Gnud do gnen nuk	We.
Bang-a-wod-jok			Of us.
Bang-en	Gnud-dok	Gnud-do-it	Thou.
Bang-ong-en	Gnud dong nud	Gnud-dong-it	Of thee.
Bang-bul-lok	Gnud-do-gnud-den	Gnud-dong-gno-rok	You two.
Bang go de bul lok	Gnud dong ong gnud den	Gnud dong ong gno rok	Of you two.

PERSONAL PRONOUNS DECLINED.

Wod-dow-ro.

Person		Singular.		Dual.		Triple.		Plural.	
First	Nom.	Bangik,	I.	Bangul,	We.	Bang-etuk-kol-lik,	We.	Bang-wod jok,	We.
	Gen.	Bangongik,	Mine.	Bang-go-de-gnel,	Ours.	Bang-ong-etuk-kollik,	Ours.	Bang-a-wod jok,	Ours.
	Acc.	Ik, Dik, or Gik,	Me	Gnul-len,	Us.	Gnellen,	Us.	Bang-gnud den,	Us
Second	Nom.	Bang-en,	Thou.	Bang-bul-lok,	You.	Bang-ud-kol-lik,	You.	Bang-ud,	You.
	Gen.	Bang-ong-en,	Thine.	Bang-go-de-bullok,	Yours.	Bang-ong-ud-kollik,	Yours.	Bang-ong ud,	Yours.
	Acc.			Bul-en,	You.			Gnud-den,	You.
Third	Nom.	Bang-nuk,	He.	Bang-a-bul-ong,	They.	Bang-tan-a-kol-lik,	They.	Bang-tan-ong,	They.
	Gen.	Bang-go-de-duk,	His.	Bang-go-de-bul-ok,	Theirs.	Bang-a-tan-a-kol-lik,	Theirs.	Bang-go-de-tan-ong,	Theirs.

Won is also given as the pronoun I. Gnar won gneal-gnen, "I believe your words"; Wodjol-a won, "Anger is gone from me." (Gnen, (W.) nuk, (K.) won, (D.) me ?)

Two forms are given in the first person plural. *Bangwodjok*, we, denotes part of a number of individuals present when that part exceeds three; *Bangetuk*, includes all present.

An, you, sing. nom. appears in the example of parsing.

Gnen, you (acc.), your, occurs in the singular.

INTERROGATIVE PRONOUNS.

Wela, who; weka, whose; winyar, what; winger, what.

DERIVATION OF PERSONAL PRONOUNS.

The components of these compounds have yet to be clearly traced. In composition they are perhaps akin to the nouns formed by elision. The dual and trinal forms most probably incorporate the numeral, *bul*, in the dual, being a contraction of bulad, two, and *kol*, in the trinal, a contraction of three (kuliba, guliba).

But this opposes the statement of Francis Tuckfield, who says the natives were able to express themselves in these forms without using the numeral adjective. This statement, we may reasonably suppose, rests on direct information given to him by the natives; but then we may infer that the blacks themselves had long forgotten the original complex nature of the compounds, for there remains this striking fact: the Geelong tribesmen, who used trinal pronouns, were found with no numeral for three. They expressed three by addition, *bulad-barp-koimoil*, two and one.*

Interjection.—Wah-wah. *Unclassified word.*—Koon-g-a-g-e. It is a parting word used by the natives. "It may be a good wish, or an exclamation expressing regret at leaving; but what it means," says Tuckfield, "the blacks could not tell." *Emphasis* is sometimes marked by reduplicating a word, or adding a syllable—tarn-tarn, winyar-ar, kollik-ka ?

EXAMPLE OF PARSING.

Yan-gag-e	an	kom-ba	an;	bar-no	gnen	ko-mer-a.
Go	you	sleep	you;	heavy	your	sleepy eyes.

Yan-gag-e, intrns. verb, future, indic., second pers., sing., to agree with its nom. *an*.

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* See *A Discovery in the Australian Language.*

An, pers. pron., sing., second, (mas. or fem.) nom. after *yan-gag-e.*
Kom-ba, intrns. verb, future, ind., second pers., sing., to agree with its nom. *an.*
An, pers. pron., sing., first, nom. after *kom-ba.*
Bar-no, adj.
Gnen, pers. pron., second pers., sing., poss. case.
Ko-an, adj., qualifying *mera.*
Mer-a, a noun, plural number.

SYNTAX.

"The order of words in aboriginal sentences," says Tuckfield, "resembles that in the language of the ancients."

Examples :—

1. Bullaid—bullaid murgal worik (Homily 9.)
   Two two nights rests he

2. Wear worik morgalu kombik
   Where stay I to-night (to) sleep I

3. Winyar kod kollik-ka
   What talk you (ternal)

4. Yan-gag-e an kom-ba an barno gnen ko-mera
   Go you sleep you heavy your sleepy eyes

5. Yan-gag-e gnubet danik ? (Obs., *d* in danik may be intrusive;
   Go water you, me *an* is the pronoun.)

6. Pointno mer drunmarnga
   Buried sun clouds in

Names of Natural Objects.

Wod-dow-ro.	Dantgurt.	Kolijon.	English.
1. Da	1. Mer ing	1. Ta	1. Earth
2. Do-ong-marng	2. Mur nung	2. Bul a da mer ong	2. Clouds
3. Gnubet	3. Bar et	3. Kan	3. Water
4. Ko-rok	4. Bo in bul lur merng	4. Kol-lad-kol-lad	4. Sand
5. La	5. Mor i	5. Tre	5. Stone
6. Mere	6. Derng	6. Na	6. Sun
7. Mondar	7. My young	7. Mur rong	7. Rain
8. Tot-ba ram	8. Born-mar-a-merng	8. Kar-at-kăr-at	8. Stars
9. Yern	9. Bar-e-nan-nen	9. Bard-bard	9. Moon.

The Seasons.

Yank-yank, Spring ; Wor-o-won, Autumn ; My-an-you, Winter.

Parts of the Body.

Wod-dow-rō.	Dantgurt.	Kolijon.	English.
1. Mor-rok-etuk	1. Be-ma-nen	1. Mor rok gnen nok	1. The head
2. Me-ent-etuk	2. Mer-ten-gnen nen	2. Gner eng nok	2. The forehead
3. Mir gnetuk	3. Mir gna nen	3. Mir gnen nok	3. The eye
4. Tar-i-je-mir-etuk	4. Tar-at	4. Tar-at gnen nok mer re	4. The eyelash
5. Wor-de mir etuk	5. (Not given).	5. Word gnen nok mer ne	5. The eyelid
6. Dernk-dernk-gne-mir-etuk	....	6. Boid-gnen nok mer ne	6. The eyeball
7. { Ko mir etuk / Tar no mer gnetuk }	....	7. Twang gnen nok mer ne	7. The eyebrow
8. Tal ang mor etuk	....	8. Bul mor ak gnen nok	8. The crown or top of the head
9. Nan-e-gnet-uk	....	9. Nan e gnen nok	9. The back of the neck
10. Gnul a kaung etuk	....	10. Gnul a gnen nok kong	10. The bridge of the nose
11. Kaung-etuk	....	11. Konk gnen nok	11. The nose
12. Bo-e-je kaung etuk	....	12. Gnarn-gne-gnen o kong	12. The nostril
13. Bo-de-kaung etuk	....	13. Bod-gnen nok o kong	13. The dividing cartilage of the nose
14. Bong e wo ro etuk	....	14. Bong-gnen-nok-wo-ro	14. The beard
15. Wor-ung	....	15. Wor-ung gnen ok	15. The lips
16. Gnelt e gnern der etuk	....	16. Tel-er-e-gnen nok gnen	16. The chin
17. Gnern der etuk	....	17. Gnan-gnen nok	17. The whiskers
18. Merp-baung etuk	....	18. Mer e wan-gnen nok	18. The face
19. Wer etuk	....	19. Wer e-gnen nok	19. The ear
20. Gnar-mor-etuk	....	20. Kan-mor-ak-gnen nok	20. The hair of the head
21. Korn etuk	....	21. Kon-gnen-nok	21. The neck
22. Gnarm-etuk	....	22. Bak korn gnen nok	22. The shoulder
23. Bol-on-etuk	....	23. Bol on-gnen ok	23. The elbow
24. Kar-am-etuk	....	24. Kar e gnen ok	24. The armpit

Wod-dow-ro.	Dantgurt.	Kolijon.	English.
25. Tar-ong-etuk	....	25. Ken e ken nok	25. The arm
26. Tar-na-etuk	....	26. Mar o mar o gnen nok	26. The wrist
27. Mur-na-etuk	....	27. Ma gnen nok	27. The hand
28. Gnur dong e mur na etuk	....	28. Tal-a-don	28. The thumb
29. Wer nen mil ark	....	29. To-bet-karong	29. The forefinger
30. Kor o wor ok	....	30. Dort mern ne	30. The middle finger
31. Bok kar a word dut	....	31. Pot-ket-dok	31. The third finger
32. Der e be mur na etuk	....	32. Ler ek gnen nok ma	32. The nail of the finger
33. Kon-kon-etuk	....	33. Kut kut gnen nok	33. The breast bone
34. To-rom etuk	....	34. Ber re gnen nok	34. The breast
35. Bam-etuk	....	35. Brem-brem gnen nok	35. The nipple
36. Tong-etuk	....	36. War-an-gnen nok	36. The belly
37. Tol or gnet uk	....	37. Tol or uk gnen nok	37. The navel
38. Wer-o-gnet-uk	....	38. War o gnen uk	38. The bowels
39. Gnel e ler er etuk	....	39. Ko re gne de gnen nok	39. The ribs
40. Gnel e mul-ong-etuk	....	40. Yel-ar-e gnen nok mul long	40. The joint of the thigh
41. Kar em etuk	....	41. Kar e-gnen nok	41. The thigh
42. Kar-etuk	....	42. Kar a gnen nok	42. The leg
43. Pon etuk	....	43. Pon gnen nok	43. The knee
44. Gnel e kar etuk	....	44. Yel ar gnen nok kar a	44. The shin
45. Lor-etuk	....	45. Bor om gum bor um gum	45. The calf of the leg
46. Barn-etuk	....	46. Barn gnen nok	46. The ankle
47. Kon a etuk	....	47. War an gnen nok	47. The heel
48. Ge nong etuk	....	48. Ken ong gnen nok	48. The foot
49. Tong e gen ong etuk	....	49. Bul gne ken ong	49. The sole of the foot
50. Wor de gen ong etuk	....	50. Word gne ken ong	50. The back of the foot (? the instep).

Natural Objects.—Quadrupeds.

Wod-dow-ro.

1. Bar ok, kangaroo rat.
2. Barn-ong, opossum.
2. Bor nong, resembles a cat.
4. Bo.
5. Gnarm bol mom, a sloth.
6. Gnur-gnur, wombat.
7. Karl, dog.
8. Ko-e-lern, } a small kind of
9. Ko-en, } kangaroo.
10. Ko-im, kangaroo.
11. Korn-um, mouse.
12. Morn gnar ok, a species of hedgehog.
13. To-an, flying squirrel.
14. Wararm, a species of rat.
15. War-en, squirrel.
16. War-er,
17. Woolard, opposum.
18. Yourn, a wild cat.

Dantgurt kud-det.

1. Karl, dog.
2. Ko-rin, kangaroo.
3. Non te, squirrel.
4. Pi-et, opossum.
5. Wring-gel, sloth, kind of.

Kolijon Gnun-det.

1. Gnarn-do, dog.
2. Kora, kangaroo.
3. Nan-kel, squirrel.
4. Pongo, opossum.
5. Wring gel, sloth, kind of.

Birds.

Wod-dow-ro.

1. Bar-it, eagle or hawk.
2. Bar-nar, duck, not quite as large as tolom.
3. Be-u-young, eagle or hawk.
4. Bit-bit-der uk, white and black in colour, long bill, long legs; found on banks of rivers where trees are.
5. Born-ing-om, a small bird.
6. Bur-de-gnul, pelican.
7. Bul-ok-or.
8. Dar-en, black cockatoo.
9. Der-be, like a quail.
10. Dorng, a common singing bird, like English gray bird.
11. Dren-ar, a parrot.
12. Gnar-om-gar, eagle or hawk.
13. Gnart.
14. Gnung-ok, black and white goose.
15. Gnurk-arm-gnurk-arm.
16. Gnura, pigeon.
17. Kan de lop, an aquatic bird.
18. Kar ol, gray goose.
19. Kar-wer, emu.
20. Kern di, the size of a hen; black plumage, white bill; cannot fly, but run swiftly.
21. Kol-ing-ar, a parrot.
22. Kol ka will, eagle or hawk.
23. Kol-par-tar-o, the size of a cockatoo; very numerous on the salt lakes.
24. Kol-war.
25. Kol-wark, nankeen bird.
26. Kon e mue a small bird.
27. Kon-o-war, swan.
28. Ko-ro-mon, a small bird.
29. Kower.
30. La-koit, a parrot.
31. Lar bar lerp, a small bird.
32. Lok-lok, eagle or hawk.
33. Mor-o-bil, owl.
34. Par-a-wong, magpie.
35. Por-ong-ge, quail.
36. Por-onget, native companion.
37. Pro-gel, a parrot.
38. Tar-ar, eagle or hawk.
39. Tar-i-wel, turkey.
40. Timp-golp.
41. To-lom, duck.
42. Tow er tow ert, small bird, found on the border of the lakes.
43. Wa-bet, eagle or hawk.
44. Wer e grow-ert, the size and colour of tolom; very numerous on the lakes.
45. Wod jok, duck, kind of.
46. Wong-ong-ul, owl; known as "Morepork."
47. Won-ok-gi, wood duck.
48. Wor-ep, like parrot.
49. Yar-en, like English black bird.
50. Yo-kep, like parrot.

Dantgurt.	Kolijon.
1. Kert ber ap, pelican.	1. Kor-ork, native companion.
2. Kore, magpie.	2. Kor-or-o, magpie.
3. Koron, native companion.	3. Mur-won-gel, pelican.
4. Nor de gel kow-ong, goose.	4. Nor-de-gong, goose.
5. Por-em-por-em, turkey.	5. Pear-wong, duck.
6. Por-in-mul, emu.	6. Porin-mul, emu.
7. To-ro-worng, duck.	7. Wred-gel, turkey.

Reptiles.

Gnar-el-a.
Kar-duk, large snake.
Koret.
Kornmil.
Kau.
Kul-or-nong.
Le-lon, lizard.
Mo-rong-it.
Mula.
Mern-di.
Nob-ine.
Warm.
Wol-gna.
Wol-op, a species of lizard.
U-rok.

Fish

Ge-ang-port, bream.
Gnul-end-wil.
Ko-ine, eel.
Kor-dir-wil.
Kore.
Merdon.
Tar-wil.
To-la-ang.
To-re-ung, salt-water fish.
To rok burt.
Wear, crab.
Weit } crabs.
Wordel }
Wer a ben, blackfish.
Yere del.
Yourn-it, a very delicate smelt.

Insects.

Kam-bar.
Mo-ron, a March fly, exceedingly numerous and troublesome. It is ravenous for blood ; neither man nor beast is safe from its attack. It is black, as its name signifies.
To-do-it.

Plants and Shrubs.

Berng-kanng, a plant found on banks of rivers. The roots supplied the natives with food at all seasons of the year.
Boi-u-rok, a small shrub, yellow flowers. The leaves are eaten by the emu.
Bol kom-bop-ba, a small green plant with leaf like a turnip. When eaten, it acts as an emetic.
Bo-rom-bo-rom, a small plant sometimes used by the natives for covering their houses.
Bor-om-bor-om, yellow flowers.
Bo-young-karl, a plant that bears a purple flower ; the root, something like a parsnip, was eaten by the natives when food was very scarce.
Bor-wor, a kind of watercress.
Gnar-a-moduk, a plant with very tough long roots, which the natives plait into belts and wear around their heads.
Kar-on, a kind of shrub.
Kar-up-kar-up, a small purple flower of which the quail are fond.
Kor-or-word-wort, a very small plant with yellow flowers.
Kol-ler, a long grass which was plaited for belts.
Mir-ark, native geranium.
Mo-ro-yok, a bramble.
Mul-a-tar-i-wel, a plant growing about a foot high, and bearing yellow flowers. The name literally signifies, " the shadow of a turkey."

Nambet,
Nar-it, a native mint.
New-lem-e-ja, a small plant with yellow flowers.
Pim-bit, daisy.
Pol-an-go, a long green plant that grows in the beds of rivers. The stalk is round, the leaf flat and narrow; it bears very handsome clusters of green fruit, about 9 inches in length. The roots are edible.
Tark, a reed.
Tar-a-ka-do, a very beautiful bushy shrub that grows near rivers, and bears clusters of white flowers.
War-war-ok, a rush used by the natives for making baskets.
Wer-an-a.
Warg, a common salad plant.
Wong-a-lok, a shrub, growing about 3 feet high, and, like the boiurok, found in great abundance on the banks of rivers.

VOCABULARY.

Ba-e-tar e ga, only stand up.
Bal mel ing, to milk.
Bam gnetuk, the nipple.
Banuk, the flesh of any animal.
Barar, grass.
Bar dop mo, to throw down.
Bar dop der e gnul, two wrestling: let us two wrestle.
Bar-i-mer-e, midday.
Bar-it,
Bar-lit, hard.
Bar-na-gnen, with you.
Bar-na, a duck not quite as large as *talom*.
Bar-nong, opossum.
Barn-gnetuk, the ankle.
Barn-barn, heavy
Barok, kangaroo rat.
Barp, and.
Ba-wot nen,
Baung, stinking.
Bel-er-en, to shine.
Ben-yek, a small bag.
Berd, name of a tree.
Ber ne, *v.a.*, to bring forth.
Bert ner ing, to divide.
Berngull, a hill.
Berk-ik, only.
Ber-wo, to twist.
Beyong, a hawk.
Bi-ang-al-a, to ride.
Bil-mal-a-bil-won*-ok, stealing woman.
Bilm-gon-ong, a thief.
Bil-po-re, or bilbore, to boil.
Bob bi, to dig.
Bob-bop, a baby.
Bob-om, a whelp; a young one.
Bog up muk, to open.
Bo-jo-wer en, weeping.
Bokariu, middle.
Bol-mo, to milk; to wring out.
Bol-mel-a, (future tense).
Bon, knee (Mossman).
Bone, a small tree.
Bono, to bite.
Borak, no; not.
Borel-a, to rest.
Bork, to cough.
Bornak, mouth (Mossman).
Borng-al-la, (v.a.), to blow.
Bowere, (*v.a.*), to fall.
Bo-wer-e-wot, cease all.
Bo-i-young, a sore; ulcer; abscess.
Brin-ba-al, rainbow.
Brit ne, (*v.a.*), to peel; to scrape.
Brit-nok (imperative)
Brit-nar-de, have shaved.
Brung-brung, gun.
Buk-ar-e-u, middle.
Bulad, two.
Bulad barp bulad, four.
Bul-la-won, an instrument with two blades; scissors, &c.
Bur-de-gnul, pelican.
Dan, hoar frost.
Da, dr dairk, earth.
Daire, the hunting spear.
Dallang, a rug.
Dam-dam, bedding of dry grass, &c.; bed; mattress.
Dark-guer-er-en, red.
Darke, heavy boomerang (non returning).
Darn-gar-en, white.
Dar-no-da, to scratch the earth.

* *n* should probably be *r*, giving worok, female. Bil-mal-a-bil-wor-ok, a thieving woman.—J.C.C.

Dar-nook, wooden bowl; bucket.
Dedabul—detable—detarbul, great; large.
Dedak—detarwa, dead.
Der-a-ba, shame.
Der en, or daren (?), black cockatoo.
Dere kol mom, midday.
Derm, dry.
Derk-war-a-bil, red.
Did-dul-a-a, calm.
Dil-o-kong-ong, a fighter.
Dol-bel-e-nun, hungry.
Dore-mert, torch.
Eramu, to-morrow.
Eram-bop-mer-e,
Ge-u-bon, to the right.
Ge wa, opposite; there.
Ge-e-wod, back there.
Gnal-la-gat, not.
Gnan-bo, first.
Gnan-gnan, no.
Gnar i wel, an adult.
Gnarwa, to hear.
Gnar-war-a-bil, relating to the fur tribe.
Gner-on-bop-mo, love.
Gno-ko-rok, to swallow; to devour.
Gnubet, water.
Gnubet-u-ren, wet.
Gnul-gnul-la-gnen } reconciled to me.
Gnul-gnul-la-nuk }
Gnul-gnul-la-a-won }
Gnun a burt na gnen, your husband.
Gnun-ye-ge, small.
Gnur dong, mother.
Gunul lom ba don, forget.
Je be weng, sparks of fire.
Jine-e,
Jur, dew.
Ka-a-le, to rustle, the noise of rippling water.
Kalif, bone awl or needle.
Kal-me-mal-me wor-en, } everywhere.
Kal-la-ma la kor den, }
Kame, that.
Kan a kan nuk, ornamental scars on back and chest of natives.
Kan de rang, a small hailstone.
Kan-kan-je, to trot.
Kar a ken, peak, or front of any head dress.
Kar-a-kin, ornamental scars on the body.
Kar am gnetuk, the armpit.
Kar e mog-en, sprinkle me.
Kare mer ing, sprinkled.
Kare muk get no we, sprinkle this one.
Kari-gnal-a-bil, Creator.
Karn-o-gnul-len, calling to us two; also Kern, &c.
Karp, a spear.
Kel-ter-a-len-tan-ong, three talking.
Kim barne, here.
Kin ja gne, over there.
Kin kud don na, saved.
Knur em ur em, feasts or dances.
Knurnen, small bag.
Kog ba gne, above.
Koi moil, one.
Kok kel ik, my expectorated matter.
Kol ba nuk, to break.
Kol bo dering, to cut.
Kol-burn-kol-burn-ure, knife.
Kol-e-muk, nurse (imperative).
Kol-e-muring, nursing.
Kol-e-mo-gnet, nurse.
Kol-le-wer-ang-gno, outside.
Kom-ba-po-nuk, above, on top.
Komering, covering.
Konda, sorrowful.
Kon-ong, soft.
Kor-a-kin, stone used for axe.
Koren-war-a-bil-karp, flint or glass tipped spear.
Koren, south.
Koren, large mussel shell used in dressing a skin.
Korine, bitter.
Kor mo, to dig.
Kor ok, sand.
Kor-o-mel-en, dirty.
Kor-on-wor-a-bil, one of the feather tribe.
Korrong, the bark used for native houses.
Korrongiu, native house.
Kow wore, saved.
Kud der, to meet, to fall in with.
Kud gella, or kud gala, to eat.
Kul bol ing kurn der ing, hasty noise made by two.
Kur-en-ye, small.
La, stone.
Lap mol ong, widower.
Leang e drun mean, ornament made of teeth and worn on forehead.
Leang-well, waddy with curved head.
Lol a boi juk, glad heart.
Lor-ger-ing, to cut (*v.a.*).
Lor-ko-mo gnet, to dive.
Ma da a won, happy.
Maga, here.
Main-main, peeled, without peel.
Male, awhile.

Ma-mel-a-gnet, to catch; to lay hold of.
Man-der-ing, to look sad.
Ma-ren-koren, a small number.
Mar-op-mar-op-ko-ren.
Me-jol-a-bil, a person in difficulty.
Me jol en bol, two persons in difficulty.
Mognet, to make.
Molga, a shield.
Mol-lal-ba, somewhere.
Mom-ba, here.
Mombam-ba, here about.
Mon-o-won-nuk, below it.
Morgala, to night, last night.
Morik, a species of grasshopper.
Mor-nin-di-u, the foot of the hill.
Mor-ok-pun yul, up hill; the top of a hill.
Mor-ong-mor-ok, a grave.
Mo ro yok, a bramble.
Mort, short.
Mo-ta-a, soft.
Moy-u, over there.
Moy um gun ong, liar.
Myone nuk, under or at bottom.
Mula, a shadow.
Mundar, rain.
Murnol, dust.
Mur-e-won, a spear-rest.
Na-i-tan, let me see.
Nam-bet.
Nan-ok, fur tribe.
Nan-wor-a-bil, one of the fur tribe.
Nan-wor-en, fur tribe.
Nar-e-bar, sacred name.
Nar-e-bert, firewood.
Nar-e-u, the top of a hill.
Ner-em-bar, bird; quadruped.
Ner-e-ne-e, down hill.
Nerim, long.
New-lem, bad.
New-lern new lern, a black polish.
New-lop-mer-ing, taking it out.
Niar, a crab.
Nil-arng-war-a-bil, the finny tribe.
Ning-ga, go backward.
Nor-koge warre, the ebbing of the sea.
Numering, to tie.
Nun-ok, tie (imp).
Pel bok, to beat.
Piyar, painted marks on a shield.
Pod-jo-uk, untie.
Pol-ar-en, sleepy.
Pon-dak, a widow.
Pone, to bite.
Pon-it-bul-gan, pointed stick used as a fork.
Por-ong-gine, short sticks beaten together at a corroboree.
Tar-a-bar ok, old.
Ta-a-kot, cut.
Ta-a-len, to fall down through sleep; to nod.
Tal-lo-ra-a, brittle.
Tal-wol, wild.
Tal-lang-a-tal-loom, mussel shell used as a spoon.
Tal-an, noose at the end of a tarn.
Tark, a reed.
Tarn, a snaring rod.
Tark-korn, string of reeds for the neck.
Tarn-jon, old.
Tarn-gar-e-u, dry; white.
Tarne-kuly, old man.
Tar-an-tar-an-kud ger ing da-a, poor.
Tar-pa-kot-me guk, to pin out a skin.
Tart, any place to put a bed on; bedstead.
Til-en-e-wer-ark, painting.
Ti-muk, the act of preparing a skin for a bag or cloak.
To-kil-mil-ing-gnet, to expectorate.
To-kol-wot, to melt.
To-kol, soft, pliable, flexible.
Tol-lom-gre-ma-gnet, to make.
Ton-gna-wort-no, to breathe heavily.
Ton-ton-nuk, brains.
Tor-ar-en, blue.
Tot-ba-ram, stars.
Tot-tol-wat-no, to dissolve.
Wad-dol-e-wod-dok.
Wagno, to work about earth.
Wa-gnul-a-bil, a working man.
Wan-ke.
Wan-ke-kot, to cook.
Wan-up-mer-ing, close.
War-an, a root.
Warm-gner-op, the flow of the sea.
Wea, wear; wela, where.
Weabul ok kot nen, to gallop.
Weing, fire.
Weka, whose.
Wer-a-a, to break; to give way.
Wer-a-la-gnen, to warm.
Wer-nen, to roll.
Wer-ner-ing (v.a.), to show; to point to anything.
Wer-up-mer-ing, open.
Wet-no, to dry a skin by stretching it on the ground.

Wet-no-kot (imperative).
Wet-ner-ing (past and present tense).
Wilong, when.
Winyar, where; what.
Wir-a-wir, waddy.
Wol-a-ba-tok, slowly.
Wol-long-wol-long-ga, deep.
Wom-ol-u, bottom.
Won-ark, the stock of a tree.
Won-gern, light returning boomerang.
Wo-o-ang, liberal.
Wor-ar-en, green.
Wor-ark, a tree.
Worm-mar-a-bil, one of the fur tribe.
Wor-nin-na nuke, the foot of a hill.
Woron gnetuk, sweat.
Woron-ki, a species of grass.
Wot-yar-al-le-wot, to barter.
Ya-ba ya-ba, noise of much speaking.
Yal-a, a nail or peg, such as was used to hang out a skin.
Yan-a-bil, a visitor.
Yan-gal-e-nut, to walk.
Yan gar a mel-a, to come back.
Ya-ya-do, to wander in spirit.
Ya-a-der-ing, wandering in spirit.
Ya-a-der-ing-mor-o-bik, my spirit was wandering.
Yar-a-gar-mor ong-gnen, your spirit was wandering.
Yelebert, liberal.
Yem-num, corner.
You-do-ro, to warm.
Youl-wer-e, to swim.
Young-al-a, to throw.
Your e mo, (*v.a.*), to press.
Your-em-der-e-gnet, press all of us.

SENTENCES AND PHRASES.

1. Ba e yan o amerjig. } Only walk about.
2. Ba me nong yan non amerjig. } Only walk about.

2*a*. Bam o won mod da gne. Give me this.
3. Bang mo ren. It is fat.

3*a*. Bar-na gnen. With you.
4. Barng-barng kud-a gnul. Divide them between us two: you take one and I take one.
5. Ba wot nen kok kil lok. Spittle is issuing.
6. Bi-ant-ne-kon ob-be-rik meant no kol ka. My forehead came against a stick.
7. Bi-ant-ne-kon ob-bo-rik ment no kol kol ka. My head came against a log as I was running.
8. Biant ne yano-Yar-ra-yaro wow nu ma tan to lon ko ra a. I am going to Melbourne; I shall return soon.
9. Bi bo gnet ma la gne. You make me laugh.
10. Bil mal-a-bil-won-ok. Stealing woman.
11. Bo-dop-mo war-o-won me juk? Do you want the skin?
12. Bo-ka gnen kor mo. I want to revenge.
13. Bok-kup may nuk? Has he opened it?
14. Bok-ko-ra le gnet wer po. Tired my back.
15. Bok-ro-re gnet mur-na-a. My hand is in pain.
16. Bok-ro-re-gnet nan e gno. Pain in the neck.
17. Bol-bol long bo-i jo gneding-da. They are mourning with crying hearts.
18. Bom bop ma karl gnu-beit-a. Drown the dog in the water.
19. Bong bong gnel ing nur. I am small—insignificant.
20. Bor am ure governor wor-he-ka am gne Barabel won-det. Boramure is governor of the blacks to-day.
21. Borm-bor-a-ba. It appears.
22. Born da mo gnen wang a bod jor op mo woi woip. The Great Spirit is pleased with you because you pray.
23. Bor not kor den. } Not finished.
24. Bor not kor en. } Not finished.
25. Bo-war e nun. Unhappy in my heart.
26. Brin-bo-ma not na-i tan. Turn it and let me see.

27. Brin-bop mo mere. The sun appears, or shines.
28. Brin e wot kitchen o gee wad kut na garden u. Go through the kitchen and round in the garden.
29. Brit nar de. Have shaved.
30. Bul-laid kud dering bul long. Two persons meet.
31. Bul la man kop ma rot. Fold it, or make it double.
32. Bung gee bok no wot-bo-rona delp ma na mo gnud den detable Moroponuk. God is displeased with the boys for throwing the ball.
33. Bung gel boy yut gnen. I am ignorant.
34. Bungilinnia. I do not understand you (Wedge).
35. De-da-won. I shall die.
36. De-da-u tan-ong we-ka jon? Who is dead? Where?
37. Der-ep-der-ep koren da. Earth is without form.
38. Der ner ing ko mo u mer i wer ko mer. I sawed it all in one day.
39. Dil it ter kud jo. I have played.
40. Din-e da we o God a do mod da. God can do all things.
41. Gangallik melinkait. We will go back. (Wedge.)
42. Gangulla. Go to your own house. (Wedge.)
43. Ge-bok ka-ak yan ga ge gnet. Come, say your lessons and go.
44. Gem-ro-re gnet-bol bo to. My elbow is painful.
45. Gin-a-bon a gnul-en kud-a-won. I forgive you.
46. Gnar ar an gnan-bo. I knew it before.
47. Gnarn ka than gnan-bo. I knew it before.
48. Gnan men no tol bop mo kin kin bil tempe wa. The dog is afraid of the blacks.
49. Gnar don tow up mal a. Let me fire.
50. Gnariwel. (Not translated.)
51. Gner en bop gnen God-a? Love you God?
52. Gner en bop me gnen. Loves me.
53. Gner en bop mer Ka-ra-ra-nuk bangik. Kararanuk loves me.
54. Gner en bop mo-it. Love him.
55. Gner en bop mo gnel-len long gong ga boy jo detable mur-um nuk. The Great Spirit loves us (three) who have a crying, or heavy heart.
56. Gner en bop mo won Moraduk. I love Moraduk.
57. Gno tap bo re. Hold your tongue.
58. Gnul a-e-ding turno detable Moroponuk, wor e ik ron deik turno gnul lok tare mering woi woip. God is not angry with you, but with the blacks far off.
59. Gnul-a-gat de-da-a. Not die you.
60. Gnul a get bung gel Sunday-u. You must not be ignorant of Sunday.
61. Gnul a gned ong kar wel len bok .. o ra-ba gned ing weing-i-u Kar wel le gned-ong kor ok ka nuk yan-gag-o-gnet wor-a-wor-iu. If we are not washed (in the blood of Christ) we shall go to hell; if we are, we shall go to heaven.
62. Gnul a gnud den kan a mo Detable Moroponuk: new lem bo ren nat gen na at pon o kud gul. The Great Spirit does not love them: they are not good because they kill the blacks.
63. Gnul la kun de di u ing ant ne wort ne moron gut ne. Not die, but live for ever.
64. Gnul la gat bul lok-ka-al-la ma-ga-gnce. You have not read these lessons.
65. Gnul lok gnen turn-no. No, I am not angry with you.
66. Gnul lok gun wer nering Mr. Tuckfield. Mr. Tuckfield is not mocking you.
67. Gnun a burt gnen gnar a a kol-o-gnet yan-e. Your husband will be displeased if you go before him.
68. Gnur dul gil e ba. Let it come.

69. Gungallianik ? Will you give me this ? } Wedge.
70. Gungallianik wanarung ? Will you give me some bread ? }
71. Jin-e-wer en Mor um etuk. God is a Spirit or Sacred Being.
72. Kal me mal me wor en Detable Muromnuk. The Great Spirit is everywhere.
73. Kan am dering bul long kin-kin-bil Detable Moroponuk barp mom-mom-nuk. The Great Spirit and His Son loves whites and blacks.
74. Kan am mo gned den Detable Moroponuk ? Do you love the Great Spirit ?
75. Kan am mo kin-kin-bil Detable Muromnuk ? Does the Great Spirit love the blacks ?
76. Kan am mo one Detable Muromnuk. I love the Great Spirit.
77. Kan am mo wod jen Detable Muromnuk. The Great Spirit loves them.
78. Ka-ar-dik. I talk.
79. Kan ko im bor den. There is but one.
80. Kan nok bol konte wollard. Two of you climb for an opossum.
81. Kar a ja my u ya a tart. Stand up, or rise from there, another good (place understood).
82. Káral ar wer yut ko mer nen. Go and tell the boy.
83. Kar-on-dow-on. I am full, or satisfied.
84. Kel-ter-a-len tan-ong bagorok. Those women are talking.
85. Kel-ter-a-len tan-ong kol-lik. Three talking.
86. Kel-ter-a-le ta-wa.
87. Ket der ing bullong pa ye. Talking in good humour.
88. Kob ba-gnar wo ma jan ba Pe der ing etuk. God knows all things.
89. Ko im ba ling. Have one occasionally.
90. Ko ing gnumo gnen kin kin bil-a. You are great, or head of all the blacks.
91. Kol ing wod ong gnul. Let us walk together, or by the side of each other.
92. Kol len bol len tar ok ik. To loosen my arms.
93. Kol o gnum de da kok bol lar mor o bik. If I die, take my soul.
94. Kol port na gnud-den wer e po Mr. Tuckfield-a. Mr. Tuckfield will break your back.
95. Kom gal e bo-le.* Two going to rest. (*Two implied.)
96. Kon-te win de-de-u kel no bon ? What did he die for ?
97. Kon-te winyar kar i ner ing amerjig barp kin-kin-bil Detable Moroponuk kog ba-gne ? What did the Great Spirit above make man for ?
98. Koon no mel len mo ro do.
99. Kud-da-an ? Shall I take it ?
100. Kud da tan ong ge la gne. Let him have it over there.
101. Kul-a-war me-juk. Take the skin with you.
102. Kul-a-won-mod-a-gne ? Must I take that there ?
103. Kum at gem (?) kud jo butter ? Do you like butter ?
104. Kum wan jor en bar-ar ? Do you like grass ?
105. Kun are en mul mul boy u ? Are you angry with me ?
106. Kun at nar-ing nerim dore? Have you seen the cows ? (No kot nar-ing tal-e-o, kom ba u no wat nok. I saw them yesterday, over there, on the other side of the river.)
107. Kun at point na mering ? Borack. Have you buried him ? No.
108. Kun-kun e mering Pejena tar-iwel ? Has your father brought a turkey to-day ?
109. Kun pun jel wer bar ? Are they gentlemen ?
110. Letter bow ok bang en. You are a person of letters.
111. Long-ga-la ar letter wa Bul lar den. Bullarden is crying because he cannot say his letters.

112. Ma la bul long bul laid ko-roka karing. Here are two who cannot read.
113. Mal bern mep ba. Let it come.
114. Mal e bo re. Stay awhile.
115. Mal it burt ne. Move over.
116. Mar en kor a len gnet.
117. Martl y gnu den pon-o. Strike you.
118. Mart-la-no yano. Soon I will go.
119. Mo ba lan. Drink I.
120. Mok bo re al ber ki gnet ok ko re Pedarong gnetuk ne nen ka wod den wer e gnum. Keep quiet and listen to the voice of God. There is a noise coming in my ear.
121. Mul-mul ba wot war-e-u. Let thy anger be removed from me.
122. Mul-mul boy yut gnen. I am angry with you.
123. Myone gut ne num dant ne. He is dead for some time—he is, indeed, dead.
124. Na-a-la-gnet tanong Mor-ron une. We will go to see Morronune.
125. Na-i-tan. Let me see.
126. Nan ne nar bul o mean nuk. He looks old in the forehead.
127. Nan gort kor en Pederen etuk. How many Gods are there?
128. Nant ni it wer ka-a-ring. Enough this evening have said their lessons.
129. Nant ne war en tur ner en by bo-re. Let thy anger or threatenings be turned from me: cease from it.
130. Nant ne wod je won. I have eaten enough.
131. Naranu wear? What is this? (Wedge.)
132. Ne re wa a ra muk. Begin again.
133. Net-ta-new rong gnen. You hide your bread.
134. Neurawaynarakant? What is your name? (S. Mossman's MS.)
135. Ning ga. Go backward.
136. No kot naring tal-e-o. I saw them yesterday.
137. No men a. That is right.
138. Nor tha-gnet bo ron gnu-beit-a. The boys are splashing in the water.
139. Not kut ne gnun kar e bo wop mo gnen. It is tiring for the legs.
140. Nu-ma-tan na-a. I have just seen.
141. Nu-ma tan wa dek wor et u. I am come from afar.
142. Ok-bo-ri-ge wo-it amerjig kin kin bil burp Detable Moroponuk kog bagne. That he might live with them for ever.
143. Pan o gned ing gnar mo rok kon nuk. Hiding herself behind her hair.
144. Pe-dan-o-gnet. Kill them.
145. Pin e wan ob o re bo-i-uk. (Not translated.)
146. Pi-yan wor-ik ma-ga nu ma-tan: yan gar a mil e Mo ron di u nu ma tan tar ran ga juo wo wop Mr. Tuckfield-a Kok-bo-ri-ge an mo-ron-a gnul-lok ganure gangage. Only came here short time. I will stay here another night before (I) go to-morrow, when I will stay to pray.
147. Point no Mer-drung-marng-a. The sun is buried in the clouds.
148. Pol ar ong new ra ma. I do not want it.
149. Pon buk bar da eram-u pe da kat to-lom. Very early in the morning I will go and kill a duck.
150. Py wod der ing. You are intruding.
151. Tal bo a ra muk. Tell it over again.
152. Tar e mo woi woip amerjig kuly barp bagoroka. With those whites and blacks who pray.
153. Tat ta k(?)o-re-gnet. We are tired. (?) Doubtful; may be r.)
154. Tart-kop mo kom nuk no Jebarok. Jebarok is smart in the.
154*a*. Tart-ko-ren. Is beautiful.
154*b*. Tert-ko yut-ne amerjig. A smart man.

155. Tol-bo-jo ma ba bal-a-la. You speak too softly.
156. To wort no mon dar. The thunder is roaring.
157. Turn no gneding Detable Moroponuk rin-rin bil gnul a ed tare eno woi woip. God is displeased with the natives because they do not pray.
158. Turn no gnen Detable Moroponuk gnul a gar wan na-wod jer mo woi-woip. God is displeased with you because you have not prayed as you ought.
159. Turn no gnen Detable Moroponuk gnul agar tare mering woi woip. God is displeased with me.
160. Turn no ket no wor e it korn deit Detable Moroponuk gnul la ga tare mering woi-woip. God is angry with the natives far away because they do not pray.
161. Turn no moin-ga-gne Detable Moroponuk gnul la gar tare mering woi-woip. God is displeased with this one here for not praying.
162. Turn no wor en kun. Are you angry with me.
163. U-rut-kut-na-ar mer-e-o gnul-a-gat win yer up mel la kol lo gnud dong gnar wel la Sunday gnul la-gat work-o yut ne. Pay proper attention to the days that you may know when Sunday comes, and not work on that day.
164. Wadok bol weranggurt nen. You two are walking about too much.
165. Wad pe der ing. We came.
166. Wa gna ba a gnel. Read properly.
167. War-a-won bo jo. Make glad my heart.
168. We a en ko-re ? Where shall I sleep ?
169. We-am bol-lo. I will go after.
170. We-ar wor-ik mor-gal-u kom bik ? Where shall I sleep to-night ?
171. We-ar wor-en mor-gal-u ? Where did you stay last night ?
172. We-a wor en ya kandel-u ? Te-ka-u. Where is another candle ? In the box.
173. We-a wort nen ya ner-im dor-e ? Where are the other cows ?
174. We ka ge o bul-gano ? Whose sheep are these ?
175. Wee-oo-ranakat neuk ? Where is he ? (S. Messman's MS.)
176. We-wor o yan-e ? Where shall I go ?
177. Will-ong bul bon bo re ? When will you two cease to run about ?
178. Wil-ong tan-ong de-da ak ? When did he die ?
179. Winger wer gnarm ger mon ? What are you thinking of ?
180. Win-ger ar gnar-e-mo.
181. Win-yar at wer kop mel la kog ba-gne kin-kin-bil barp amerjig kog bagne ? Ting a li ja wot. What do the whites and blacks do above in heaven ? All sing.
182. Win-yar jon born dop mo Detable Morropuna ? With whom is God displeased ?
183. Win-yar turno bangik mon Ron ron a (? Kon son a) ? Who am I displeased with ?
184. Win-yar turno, Mr. Skevington, Rer tin u ? Jin baaring gnar-i-wel turn-er-ing Ror bar ar ing boron barp bagorok. Only with the men; he is pleased with the boys and the women.
185. Win-yar kod kol lik-ka ? What are you (three) talking about.
186. Win-yar tan-ong kop mir ge ga bon ? Who has taken him up there ?
187. Win-yer at kud jering kon damper kon rice ? What have you to eat—damper or rice.
188. Win yer jun torno detable Moroponuk ? Gnul la woi woip gort nen kin kin bil. Who is God angry with ? With those who do not pray.
189. Win-yer bol kud jo ? Kon butter barp new-rong. What have you been eating ? Bread and butter.
190. Winyer jon-gnun gnen Ro-im be ra len ? Which one shall I give you ?
191. Winyer at ka-o ? What did you say ?

192. Winyer at kop me? What are you to do with that?
193. Wi po eding turno detable Moroponuk. He continues to be angry.
194. Wob o gnu bet Bian a bul a. The horse is waiting for the water.
195. Wod jol a won. Anger is gone from me.
196. Wong o gnet gnul o gil dar-nuk-a. Stop the hole in the vessel with glue.
197. Yan a an non gul long ton. I think I shall go.
198. Yan e nuk gnal a gar gnur e wer burt ne-u. Go to the bullocks. Straight on.
199. Yan ik i do an. I will go with you (Wedge).
200. Yan gag e gnu-bet-dan ik? Will you go for water for me?
201. Yan gage dan bo-ra-re. I will go; you sit down.
202. Ya man non o gal e. I think I shall go.
203. Yan o gnet kol la la wa bong e gnet koim. Let us all go and surround the kangaroo and kill it.
204. Yan o gnet pi ar a kud ge o gnet mer ne. All go and eat murnong.
205. Yar ra wo-u wa-de an e-ram-u. I shall go to Melbourne to-morrow.
206. Yingi-ya al yan nuk worong kudjo wad den bo. Sing another tune to destroy all my heaviness.
207. You kop mer ing gnud den.
Peda leangnuk. Beat the teeth.
Pedelatantanong. Strike us.
Pedelagnu lentanong. ,, (dual).
Pedelawawaden } ,, (trinal).
Pedel agne lentanong }
Wa-a-la-bil-ar. You are a giver.
Waalabilud. He is a giver.
Waallabilworok. She is a giver.
Werk kert gnet po-da-a. Put wood on the fire.
Werkerp ma kop (*imp.*). Trim the fire.

SCRIPTURAL PARAPHRASES.

The Fall.

1. Kok-bol-ing karing gnar ing allok Gnul a gnen karing kol ba gne Pedering etuk Kok baling gnar-ar-ing kep-ma-la. Jat-ga-ge gnul-en. Kun-on gnen karing Kok-bal-ing gnar-a-ing.	1. (Not translated.)
2. *Devil:* Kud-jar-a-bol ong kin-u, wer-ok buk-kar-a wod det. Kun u-ben-uk moda. Kud-jol-a bol ko-im burt kal-e-u.	2. *Devil:* Eat two of the fruit in the midst. It is very good. Eat one only.
3. *Eve:* Bo rok kong mart lo gnet de-di-je.	3. *Eve:* Not eat, because all will die.
4. *Devil:* Borok gnal a gal de di je; mart-lo gnar-wel-a-wol-a kol-ba-gne.	4. *Devil:* You shall not die, but soon be as wise as He above.
5. *Eve:* Mart lo torne wa ra nuke.	5. *Eve:* If I eat I shall be diseased in my bowels.
6. *Devil:* Bungel-bur-en nu do. Mart-la-ing nar a la wol-low-ing kog-ba-gnu-na-a la-i-u wor et get-u gne yan-e-nuk.	6. *Devil:* You are ignorant. Eat, and your eyes will be opened to see like God—to see a long way. Go and take it.

7. *Eve:* Gun-u.
8. *Devil:* A! A! Ko-im bop ma lar war.
9. *Eve:* Nan gurt nuk?
10. *Devil:* Kun-u-ben uk-nun-ong.
11. Gnan-bo kud-jer-ing Eve wan u wa a la nuk Adam.
12. *Adam:* We-la mug-jer-ing ka-ma-ja-gne?
13. *Eve:* Bang ong ik.
14. *Adam:* Win yar-gno?
15. *Eve:* Kol-ba-gne kud jok-ba kam-e kun u ben-uk. Gnal a gat-moy-u mo we ban jo mo tong.
16. *Adam:* We-la gnul-en mir-o? Nud-o-na-a men?
17. *Eve:* Moy u mel-en kon.
18. *Adam:* Na-ok mom ba-gne na-a lar ok kap-me wa de gnul. Ne le gnul kore u ge go gne gnard borok ko-rep kod bo.
19. *God:* We bol we ar? We-la bol-nel-li-jo? Kon-bol-bil mil ik?
20. *Adam:* Mur ne jur ren nan.
21. *God:* We-la gnen ka ung bar dar ong tal-ong? Kun bol kud-jer-ing buk-ar-a wordet? Kan bol? Nan gnul lok-bol kud-jol-a.
22. *Adam:* Young gag-a-dik ge la gne bag-orok-a, kud-jer-ing ant nan.
23. *God:* Win-yar-ar kud-jer-ing?
24. *Eve:* Karing-ik ge la gne bojel-gna punjel-kar-ne.
25. *God:* Kon te win-yar-ar karing ba-go-rok-a? Gnal-a-gat born dop-mo ba-go-rok-a. Nar-o-der ing bul-ong, nar-o-der-ing wol ar ne mom-om gnen-turno ma la gne barp bob om nuk tum der-e-bul ong mom mom gnen. Bob-a pont nuk bol-mo mor-o-ko mom-om-gnen bol-mo bar no-nuk mom-om-gnen.

7. *Eve:* I go.
8. *Devil:* Yes! Yes! Take one of the fruit.
9. *Eve:* Is it good.
10. *Devil:* It is very good.
11. Eve ate first, and then gave it to Adam.
12. *Adam:* Who has taken this fruit?
13. *Eve:* Mine.
14. *Adam:* Where did you get it?
15. *Eve:* Up there. Eat it; that is very good. I do not tell a lie. It will not hurt your belly.
16. *Adam:* Who sees us? Can you see?
17. *Eve:* Not see; or you have told a lie.
18. *Adam:* See up there; let us go and hide ourselves; come, go there.
19. *God:* Where are two of you? Where have you hid yourselves? Have you stolen from me?
20. *Adam:* I am naked.
21. *God:* Who told thee that thou hast no clothes? Have you eaten of the fruit in the midst of the garden? Have you, after I told you not to eat of it?
22. *Adam:* The woman who is there gave it me, and I did eat.
23. *God:* What did you eat for?
24. *Eve:* The old Devil told me to eat.
25. *God:* What hast thou been talking to the woman for? No peace will again exist between thee and the woman, but enmity, and between thy seed and the seed of the woman. It shall bruise thy head, and thou shalt bruise his heel.

The Commandments.

Yan. 8, gar xx.

V. 2. U-rid-u-ren nun kom-im-bo-ren nun. Grar weit-u ren nun (kod be one) Wor-ang mor ang, wol-e mongnud-den. Kom gar a mon ya-a-da (or Egypt).

I am and there is not another like me. One over all—the Supreme, who delivered you from bondage in another land.

3. Ko-im bo ren gnue bo ra ka-a-kun-til gnar it.	Thou shalt have no other Gods before me.
4. Gnul-la-get wa-gna-ba mul-a-wik gnul a kun wa-gna-la mul-a nuk tot bur ram. Gnul a kun wa na ba mula nuk yeron gnula kun wa gnala mul-a muk-mir-e-o, gnul a kim wa gna la mul-la-nuk ya-rit da-a gnul a kun wa gna la mul a nuk wa re.	
5. Gnul-la-gat bul-laid pun go re kat der e gnel wor-o-wor-o-u barp di-u my-u-gnel barp war-e-u ket der y el det. Kao wot-boy-dik, dil bol la ya gnen boid ge o war ware, dil bel la ya gnud den, kod korm ma la gnud den, gnart kar en gage barp yar nam delp ga-g-e.	Thou shalt not bow thyself, nor speak to the heavens, nor to the earth nor to the sea but to me; for I will punish the fathers and children and children's children.
12. Gner-en-bop-mo kot pe-der-a-gnen barp gner-den, mel bo re kar di-u dop ba la gnen youn ger en gnen Pedering etuk.	Love thy father and mother, and thy time shall be long upon the land which the Lord hath given thee.
13. Gnul la get dil bol la kan ban-nud.	Thou shalt not kill.
14. Gnul la get kom-bar-don-go-ren bul long.	Thou shalt not commit adultery.
15. Gnul la get bert-na gnul.	Thou shalt not steal.

The Lord's Prayer.

(Wod-dow-ro ?)

1. Gnur-ar peder-ik kok bo re je wor-a-wor-a. Gnur ar peder-ik,	Our Father which art in heaven,
2. Wang-go-re nar e gnen ;	hallowed be thy name ;
3. Gnar wo gnen kar-ong-a yan kag e a kul-a (kud ki ge gnen tan ong) ; gnar e wel e wer i je are wol a wor en wor-a-wor-a won de et.	thy kingdom come, thy will be done on earth as it is in heaven ;
4. Young-ga-ge a-wod-jok war e mir-e-o,	Give us this day our daily bread,
5. Wang a ge-*en boi jo wod jok wor-a-wor-a woren nau (bo i jo nik) (Gnul-a gat ure bo b† are yant nuk kuly) wol-a wang a la bang-wod-jok yant nook kuly.	and forgive us our trespasses, as we forgive them that trespass against us.
6. Gnul a gart wod jen kop e mal-a new-lem go ra an ;	Lead us not into temptation ;
7. Bene mo wod gen tan ong wor-a-wor-a wer ko-rik.	deliver us from evil.

* c e? May be *gun* or *l* † Letter illegible.

Another Form—Incomplete.

(Kolijon ?)

1. Bort nuk mar mar kan-bon nad-don a now wol look gne bort nuk ma-moit,	Our Father which art in heaven,
2. Gnu-ra-nan-da nar-e gnen ;	hallowed be thy name ;
3. Wad-ge-no to-wardo wad wad de tar gnud dun yar-o-ni-ong now-won kan bon-o-ni-e ;	thy kingdom come, thy will be done on earth ;
4. Komo nan nen ge rang a kar gnar-lar tar ar wart.	give us this day our daily bread.

Homily—A Fragment.

1. Kan am mo kin kin bil Detable Moroponuk ?	1. Does the Great Spirit love the blacks ?
2. Kan am der ing bul long kin-kin-bil Detable Moroponuk barp mom-om-ik.	2. The Great Spirit and His Son loves whites and blacks.
3. Kan am mo wod-gen Detable Moroponuk.	3. The Great Spirit loves them.
4. Wang-gore wor-en-it amerjig barp kin-kin-bil kan o mo wod jen.	4. Good whites and blacks the Great Spirit loves.
5. Gnul-a-gnud den kan a mo Detable Moroponuk new-lem boren nat gen-na-at pon o-kud jul.	5. Not them love the Great Spirit (*i.e.*, The Great Spirit does not love them) that are not good because they kill the blacks.
6. Winyer op mel la Jesus Christ-a kun kar wel la mor om dik kol-la yal look ki-u ?	6. What does Christ do that he may wash our souls. Does he take them to the water ?
7. Borok-ka. Wa-da-a wor-u-wor-o wang-a la mom om nuk pe der a gnun nuk wol a amerjig kort-nik.	7. No. He came down from heaven and was made in the likeness of man.
8. Det kort ner ing tan-ong ya amerjig brin kag ik kor ak ka nuk kar wer ing tan-ong mor-om bul etuk.	8. He was killed by white men, when blood was shed to wash our souls.
*9. Bul-laid-bul-laid mur-gal wor ik kar it gar a mel-e-ik wor-o-wor-i-u.	9. After three nights he rose from the dead and returned to heaven.
10. Kon-te-win-yar de di u Jesus Christ ?	10. Why did Christ die ?
11. De-da-lik kor ok ka nuk kar wel le amerjig barp kin kin bil.	11. He died that whites and blacks may be washed in his blood.
12. Kon-te-win-yar kar wel le kor-ak-ka nuk Jesus Christ-a amerjig barp kin kin bil.	12. What for the whites and blacks wash in the blood of Christ ?
13. Gnul a gned ong kar wel len bok po ra-ba gned ing weing-i-u Kar wel le gned ong kor ok ka nuk yan gag o gnet wor-a-wor-i-u.	13. If we are not washed we shall go to hell ; if we are, we shall go to heaven.

* Bulad-barp-bulad, four, is given in Eyre's *Journals of Discovery*, vol. ii, p. 400. Bulaid repeated without the conjunction, as in 9, is perhaps merely emphatic. Three, in the statement, should of course be two.

14. Gnul a ga youn dor alla weing-i-u.	14. Do not send me to hell.
15. Wang ar lar mor-o-bik.	15. Make my soul anew,
16. Mor-o-mor-o-bol bop mok boy jik.	16. Make my heart to feel.
17. Gnar won gneal gnen.	17. I believe your words.
18. Ka a ken gnar wel lan gneal gnen martlo.	18. Speak to me, and I shall know or believe your words.

Grace before Meals.

Wang-ok mān kud jol-a-bik wor-o-wor-o-won det jop pan nar Pe-dong. Amen.	Sanctify this food to my use my heavenly Father.

Grace after Meals.

War-ing-ar ên wang-go-re war gnen; wa la gnen gneal-a-nik kul-lar gneal-ik Pe-dong.	Given me good food you; take my word, or thanks, which I give you in return, Father.

APPENDIX.

Wod-dow-ro words, by Samuel Mossman, from his MS. notes, now in the possession of Mr. G. M. Hitchcock, J.P., Geelong.

Bidzerinbulong. To fight.
Bon. Knee.
Bormak. Mouth.
Dinang. Foot.
Doorapneuk. Body.
Duribizinang. Toes.
Gang. Nose.
Gouronok. Neck.
Iremourk. Hair.
Jellang. Tongue.
*Karribunnalong. Leg.
Koinyebaneuk. Very good.
Kudgulwurnay. To die.
Kurtgurtgully. Young man.
Liangeduk. Teeth.
Mirrabang. Face.
Mirrouk. Eyes.
Murrineuk. Head.
Naramana. Eyebrows.
Narimilly. Dancing.
Neulam. Not good.
Neurawaynarakant? What is your name?
Quambie. To sleep. (Komba: Tuckfield's List.)
Warwar. Man.
Weeooranakatneuk. Where is he?
Weeringaduk. Ears.
Wooroo. Lips.
Yingally. Singing.

* C in the MS. K substituted in the four examples.

Section G.

ECONOMIC SCIENCE AND AGRICULTURE.

PRESIDENTIAL ADDRESS.

By R. M. Johnston, F.L.S., F.S.S., Government Statist of Tasmania.

(*Delivered Friday, January* 7, 1898.)

CONSUMABLE WEALTH.

The term "wealth" is the principal source of confusion in all social and economic questions. The manner in which the term should be used or interpreted depends entirely upon the nature of the question with which the generic word "wealth" is brought into relationship or conjunction. Owing to the backward state of Economic Science, as compared with the various branches of Natural Science, the phrase "the wealth of a country" covers widely divergent conceptions.

Even if we exclude the free or unmonopolised gifts of Nature, which form no element of "exchange value," there are still at least three different conceptions of the phrase, "the wealth of a country," the lack of a precise grasp of which is the rock upon which nearly all so called socialists become wrecked in confusion and absurdity.

(1) The Statistician's "wealth of a country" may mean, either private wealth or public wealth, or both; but in any case, it rarely embraces more than one-third of the real monetary value of the total wealth in exchange of the economist; and certainly seldom more than 2 or 3 per cent. of the corresponding monetary or exchange value of the total capital value of the true wealth in exchange of the economist.

It altogether excludes the principal primary source of all wealth in exchange, viz :—The existing productive personal services of man, although the annual monetary value of the latter is fully three times as great. For example, in Tasmania the annual value

of wealth consumed, mainly the direct product of man's personal services and of his auxiliary machines, is equal to £7,274,300, and therefore must have a *bonâ fide* capital value of say £145,486,000; whereas, at most, the Statistician's private capital wealth of the Colony only amounts to £40,000,000, or merely 27·49 per cent. of the capital value of the Colony's real consumable wealth in exchange.

Similarly we have for the following countries a corresponding analysis of their wealth accordingly as we refer the term to the two very widely differing conceptions to which the same phrase or term is often loosely applied :—

THE Wealth of the Country.

Country.	The Product of Anterior Labour Agencies (Fixed Capital). The Statistician's Wealth.		The Product of Anterior and Current Labour Agencies. The Economist's Real Wealth in Exchange.	
	A. Capital Value.	B. Annual Value.	C. Capital Value.	D. Annual Value.
	Mil. £.	Mil. £.	Mil. £.	Mil. £.
United Kingdom ...	10,037·00	501·85	25,612·00	1,280·60
New South Wales...	412·00	20·60	1,364·58	68·23
Tasmania	40·00	2·00	145·49	7·27
	CENTESIMAL.		RELATIVE.	
United Kingdom ...	37·43	1·96	100	5·00
New South Wales...	30·19	1·51	100	5·00
Tasmania	27·49	1·37	100	5·00

WEALTH IN CONSUMPTION.

When the Socialist complains of the unequal distribution of wealth, such is the confusion arising from the various applications of the term, that he is often misled by references to facts which have, at best, only a partial relation to the subject to which his attention is particularly directed.

If he bases his conclusions on the "Statistician's Wealth," and especially so when restricted to the Statistician's Estimates—of the capital value of the private wealth of the country—he is sure to be misled; for the Statistician's figures do not embrace any element of wealth which, during the year, is utilised or devoted to the immediate consumption or satisfaction of man, nor for the immediate consumption of man's auxiliary aids and instruments engaged in the work of reproduction.

They are confined strictly to those articles of wealth which are fixed or set apart from consumption as instruments for the production, transfer, modification, or protection of the current year's consumable goods and satisfactions for man himself; and also for the current year's supply of consumable goods, required as food, renewals, repairs, and shelter by man's instruments, whether animate—as horses, cattle, sheep—or inanimate—as in the coal, oil, materials required for the production of energy in his engines and machinery, engaged constantly in the production, transfer, or modification of the essential utilities of man's life—viz., food, transport, shelter, warmth, clothing, comforts, luxuries, ease.

Moreover, the Statistician gives the capital value of these instruments; and therefore no just comparison between this personally non-consumable part of a nation's wealth can be made, until the several parts of the total wealth is stated in a corresponding measure of monetary or exchange value.

For if we capitalise the value of fixed instruments, we should also for comparison capitalise the annual production of wealth—also annually:—

> (1) Distributed and consumed; or (2) annually converted into fresh fixed auxiliary producing, transporting, modifying, or protecting instruments.

Thus, although the capital value of fixed instruments in New South Wales, is estimated at 412 millions, it only represents 30·19 per cent. of the corresponding capital value of its annual productions of fresh wealth of consumption; for although the annual value of the latter only represents 68·23 millions, its capital value represents a sum of 1,364·58 millions, or 3·31 times the value of the Statistician's wealth of land, houses, machines, and other fixed forms of the mere producing agencies.

Even while it is admitted that the element of national wealth contained in the fixed producing instruments (viz., 30 per cent.) may be confined to the ownership—not consumption—of a comparatively small number of the community, this circumstance does not afford the slightest information as to the distribution of the fruits of the various producing agencies, among which man's current directing as well as current muscular services play a prominent part; and it must not be forgotten that the latter, together with the "anterior labour" and skill of man now currently stored or incorporated as detached claims in auxiliary producing instruments, constitute the main elements which give price or monetary value to the current wealth in exchange, produced, whether for consumption or for fixed uses of future production.

From such obvious considerations we are able to detect the common fallacy among Socialistic writers and others, who invariably measure the distribution of the wealth created purposely

for human consumption and personal satisfaction among the wage-earning classes by the proportions which the ownership of fixed or monopolised capital-producing instruments, &c., show among the people generally.

The fallacy, however, is so thoroughly interwoven in the literature and sayings of the mass of the people that it is almost impossible to expose its absurdity; but when we consider that man lives by current or annual productions *per se*, and not upon fixed capital or their nominal values, whether annual or capital, and when, moreover, we discern that services currently rendered, whether by instrument, skilled mind or hand, constitute the base of what forms the purchasing power or claim over wealth being produced for consumption and personal satisfaction, it is only then we are able to perceive that the distribution of real wealth, so far as man's needs and satisfactions are concerned, are determined, not as fallaciously assumed by the proportion of ownership which each man holds of the statistician's wealth—*i.e.*, the fixed nonpersonally-consumable instruments, and which the owner no more consumes than the servants who control them—but strictly by the express measure which services of various degrees of exchange value have enabled each worker to constitute a claim upon the aggregate of all such services whose values are contained and incorporated in the current production of actual wealth.

It is not here contended that the time labour of each individual labourer or instrument has the power to create equality of claim in correspondence with time effort: that is too obviously unequal; but it is contended that every such effort, usefully directed, constitutes a definite claim, and, therefore, the true distribution of wealth in the community—wealth in consumption being the major factor—can alone be accurately determined by the average annual earnings or claims upon wealth. The proportion of fixed wealth owned by individuals affords no clue to current distribution of total wealth. It can merely show how the 30 per cent. devoted to fixed instruments is distributed.

If the proportion be large it insures probably a claim to the extent of 4, 5, or 6 per cent. of his capital upon real wealth, upon which the owner exists, and which may give a considerable purchasing power to the individual without any current personal exertion; but it must not be forgotten that the fixed capital of a manager may be almost nil, while his skilled directing services may enable him to create a yearly claim of £1,000 value upon wealth produced for immediate human uses, while the fixed instrument of a helpless widow, owner (say) of £10,000 capital value, may only afford her a claim of half the amount (or £500) falling to the manager, whose fixed capital is reckoned as nil in the usual Statistician's estimates of the capital wealth of a country.

DISTRIBUTION AND CONSUMPTION OF WEALTH.

I have elsewhere observed that there are many other fallacies current with respect to the creation and distribution of wealth. If all the enormous volume of wealth created year by year, viz.:—(1) Stored fruits of anterior labour and skill (*i.e.* capital), of which steam-engines alone represent approximately the work of 1,000,000,000 men, or more than double the physical energy of the whole of the world's breadwinners, engaged in the creation of fresh wealth; (2) current labour; and (3) the gratuitous gifts of Nature. If these were directly devoted to consumption or immediate enjoyment, no doubt the proportion per head allotted to the industrial breadwinner would be small indeed in comparison with the rich. But the human body, whether rich or poor, can only consume or assimilate a limited quantity of food per day. The old, sickly, and very young cannot consume or assimilate as much as the strong, healthy persons of youth and prime of life. Health and hard physical labour cause the body to burn more food; and the greater tear and wear involves a greater consumption of the products of the sheep and of the cotton plant, just for the same reason as the requisite energy of a heavily loaded engine climbing a steep and curving grade, involves a much greater consumption of fuel and a much greater waste of parts in tear and wear than a lightly loaded engine traversing the straight levels of a railway.

From this reasoning it is almost conclusive that a strong, healthy navvy can and does consume more weight of the products of the soil, of the flour mill, and the weaver's loom, than the less robust city clerk or the brain-worried financier or statesman; the mere quality or rarity of some of the materials consumed by the rich is comparatively insignificant, and scarcely involves a greater tax on the soil, on the capitalist's machines, or upon the workman's labour.

Further, it can be demonstrated that the capitalist's steam engines alone perform more work than twice the number of the whole working population of the earth; and as these only form a part of the capitalist's machinery, tools, and instruments engaged in the production of consumable wealth, and known vaguely or concealed under nominal values as in "Statistician's Capital," it can be demonstrated satisfactorily that it would be utterly impossible for the rich capitalists to abstract from his profits the same proportion of his income towards personal wants and enjoyments as the poorer workman does. On the contrary, what he can directly consume personally of the primary satisfactions which make up the bulk of consumable wealth, is limited by the same natural laws as is the personal consumption of the humblest workman; and the necessities of repairing the tear and wear of the

capitalist's costly machines (fixed wealth or capital) and the passion or necessity to continually add to the number and power of his auxiliary machines, and to protect and keep them ever at work, must inevitably abstract the greater portion of his increasing or decreasing profits, and which the thoughtless and the mere literary emotionalist imagine are altogether absorbed in personal consumption.

What is usually termed "the enormous accumulations of wealth in our times," "the riches of capitalists," do not consist of fine houses, luxurious equipages, money, or grand parks, or, if so, it only forms a most insignificant portion of it. The great bulk of the nominal and real wealth of capitalists consists of land improvements, mines, railways, tramways, ships, canals, stores, warehouses, manufactories, machines, tools and instruments, &c., themselves; and though rightly included in the aggregate fixed wealth of a country by Statisticians, these do not in any sense enter into the personal consumption of the rich owner any more than they enter into the personal consumption of the workman engaged in connection with such forms of national wealth.

The mass of Socialist writers wish us to infer that the "toil" of the "masses," "the lower ten millions," alone "is the active factor that produces all wealth." Entertaining such a view, it is not remarkable that they should regard the riches of the "upper ten thousand" as a hoard mysteriously and wrongfully abstracted from the forces actively engaged in producing wealth.

If by the toil of the masses they mean that all the physical forces requisite to transport and transform natural materials to suit the needs of man, they are manifestly wrong; for (exclusive of the mere gratuitous forces of Nature, such as natural chemical changes, multiplication by the mysterious forces of life, sunlight and heat forces, gravitation, the rain, dew, and the fertile soils, and the animal, vegetable, and mineral products in their natural state and position) there are the active forces set in motion, not of the expenditure of muscular energy, but of mental and moral force, exerted by men of forethought, of skill, of invention, and of the provident who designedly saved from immediate personal consumption, and devoted such savings purposely to the construction of mechanical and other aids devised or discovered by skilled minds, whereby the forces of Nature, such as gravitation, chemistry, steam, water, wind, electricity, leverage, lower animals are so captured, tamed and drilled, that they now exert a physical force in the production of man's wealth—whether in the way of transporting from place to place, or in transforming materials from the natural raw state to the highly finished—compared with which the brute or muscular force actually exerted by all the working men of the globe, forms the most insignificant fraction.

I have already pointed out that it is estimated that the steam engines alone now engaged actively in the production of man's real and nominal wealth, represent double the potential muscular force of all men in the world at the present time, exceeding the muscular force of men actually engaged in the production of man's wealth by, perhaps, three or four times. The mere muscular pressure of a man, which, on his part, only exhausts his muscular energy by what would be equivalent to the movement of his body by one step, may, and, in fact, now incessantly does liberate and set in motion a transporting force in one machine equal to the combined total muscular force of from 200,000 to 500,000 men.

At the present moment, on the railways of Pennsylvania, in America, a single engine conveys a load of 1,500 tons 29,927 miles in one year. It would, in a primitive stage—say by the strong African carriers of Stanley—take the mere muscular force of 465,360 men, carrying 60 lb. weight, and travelling at the rate of 12 miles per day, to accomplish the same work in the same time; and even though they only received wages at the rate of 1s. per day, it would cost £6,980,400; at 5s. per day it would cost £34,902,000. The single Pennsylvanian engine, however, carries the same load, viz., 1,500 tons 29,927 miles within one year for the sum of £92,721, or ½d. per ton per mile—that is, a single modern locomotive exerts as much wealth-producing energy as could be effected by the whole muscular force of 465,360 strong men, and at $\frac{1}{376}$ of the nominal cost. Even if we went into refinements, and attempted to abstract the human muscular energy expended in the manfacture of the engine from raw materials, and the consumption of stores and materials consumed in the work, also partly the produce of the muscular force of man, it would be more than covered by the subtraction of the muscular energy of 600 men, leaving still to the credit of the single machine a balance of natural physical wealth-producing energy—*i.e.*, non-muscular—equivalent to the muscular energy expended of 464,760 men during one year.

When, in addition, we think of the spinning jenny, the electric telegraph, the sewing-machine, and the thousand complicated forms of machinery, such as the Naismith Polka Hammer, which, by the slight pressure upon a handle, can instantaneously pour 100-ton blows upon ductile masses of iron, we can have some faint conception of the immense mechanical and natural forces ever at work in civilised countries, outside of the muscular force exerted by man, and contributing their giant share of the physical agencies which give commercial value to man's wealth. It is clear, therefore, nothing can be further from the truth than the assumption by the majority of Socialists, that the energy of the "lower ten millions," or "the masses," alone represent the active factor that produces all wealth.

The brains of man can alone be credited with invention and discovery, not his muscular power. It is to the accumulations of savings from personal consumption by the labourers and others of former times that we are indebted for the necessary stores devoted to the construction of the powerful and ingenious mechanical and other labour-saving auxiliaries now engaged in aiding the current labour of man, and not, as falsely assumed, to the mere muscular energy and labour-time exerted and devoted by those who happen to be the labourers or workmen of the present hour.

Recent estimates of the measure of energy exerted each year in the production, distribution, and necessary modification of consumable wealth—the satisfactions of man, by capitalist's steam power machines alone—are approximately equivalent to the maximum energy of about 1,500 million persons, of whom it is estimated that there are only 600 million breadwinners. We may be perfectly safe in assuming that the energy exerted by all classes of capitalists' auxiliary machines to be equal to the maximum energy of 1,200 million breadwinners, *i.e.*, equal to twice the physical force of all living breadwinners of the globe. In Tasmania at the last census the number of breadwinners under £150 income per year numbered 58,726 persons. These, for purposes of illustration, may be safely taken as the wage-earner group. The breadwinners £150 income per year and over, numbered 5,404; and this group, for rough purposes of comparison, may be taken to represent the capitalist group. Now, if the capitalists' energy machines engaged in the production of consumable wealth be taken to represent twice all the available force of man, their equivalent in Tasmania would be represented as that of 128,260 breadwinners, thus :—

Relative Value of Physical Energy exerted by the various agencies engaged in the Production of Consumable Wealth.

		per cent.
A—Breadwinners under £150	58,726	30·52
B—Capitalists and others over £150	5,404	2·81
C—Capitalists' energy machines	128,260	66·67
Total energy employed in the production of consumable wealth	192,390	100·00

From this table we perceive that if we ignore the claims of intellect and ability, and reserve ourselves to the mere physical forces devoted to the production of consumable and other forms of wealth, the wage-earner's contribution only amounts to 30·52 per cent. of the whole of the necessary energy required to produce that volume of consumable wealth, which would yield each class and individual that standard of living and comfort to which they have been accustomed.

Now if it can be shown that the wage-earner group (under £150) receives a larger proportion of the consumable wealth in each year than the proportion of physical energy contributed by such in its production, it most effectually disposes of the sentimental complaint so frequently put forward by the Fabian school of writers, viz., "the lower ten millions, whose toil is the active factor that produces all wealth, not of the upper ten thousand, who in some mysterious way manage to get rich upon that toil."

This inaccurate statement can easily be refuted in a very simple manner by ascertaining what proportion of consumable wealth, per year, is appropriated or absorbed by the three principal agencies engaged in its production. The best and surest means to gauge what measure of reward comes to each separate group is to determine what proportion of the total annual income is appropriated by each group respectively.

This has been very closely determined by the writer so far as Tasmania is concerned, and is shown in the following table relating to distribution of national income for the year 1891 :—

Share of National Income appropriated or absorbed by the various agencies employed in the Production of Consumable Wealth.

Producing Agencies.	Comparative value of physical and other energy exerted in the production of consumable wealth.		Approximate share of title-to consumable wealth absorbed or appropriated by the various agencies engaged in its production.	
	Energy Equivalent.	Per cent.	Amount.	Per cent.
			£	
By breadwinners, under £150 per annum	58,726	30·52	5,027,074	69·11
£150 and over (capitalists' class)	5,404	2·81	1,138,800	15·66
By capitalists' steam and other auxiliaries	128,260	66·67	1,108,466	15·23
Total	192,390	100	7,274,340	100

A careful study of this table shows that, so far from the capitalist class being enriched at the expense of the wage-earner, the very opposite is the truth; for instead of a reward being allotted in proportion to his share of energy contributed, it has been increased fully 100 per cent., energy expended being only 30·52 per cent., while his share of rewards represents 69·11 per cent.

This improvement of his position is solely due to the fact that the more economic physical agent engaged in production only absorbs 15·23 per cent. of the consumable wealth, while its

share of the necessary energy engaged in production amounts to 66·67. It is true the capitalist receives relatively a larger individual share of the capitalist's own machine production; but it is impossible for the capitalist to personally absorb more than about three times the amount of the average breadwinner. The remainder must perforce go to improve the reward and condition of the ordinary breadwinner. The higher the percentage of energy contributed by the capitalist's machines involves of necessity a corresponding reward to the ordinary breadwinner, while the proportion going to the rich capitalist must by a like necessity remain almost stationary in comparison.

It cannot be too strongly asserted, therefore, that the greater reward of the labourer in relation to the increasing command, which, during the last century, man has obtained over the forces of Nature, steam, electricity, and improvements, in labour-saving machinery, multiplying man's muscular power in the production, transport, and manufacture of necessaries and satisfactions, three to four and in some cases many hundredfold. In proportion as these auxiliaries have increased in the production of any one necessary product, the amount of physical human labour engaged in its production has decreased individually,* and to the liberation of labour formerly necessary to produce the barest essentials of life are we indebted for the vast category of new comforts and satisfactions, the attainment of which was utterly impossible to the mass of human beings when the production of food alone—the great primary industry—absorbed nearly the whole force of man's muscular efforts and his time. This is the true reason why there are relatively fewer labourers engaged on the land in England at the present time than there were formerly; for I have elsewhere clearly demonstrated that 5·35 hands per 100 acres produce more than it was possible for half as many more fifty years ago, and more than double their number could produce a 100 years ago. This is the reason, too, why one agricultural hand in America can produce as much as three average hands in Europe; and this reason also, combined with cheapened transport, accounts for the decreasing acreage in crops in England, for the greater economy in the production of cereals in America has gradually forced down the price of wheat from 56s. 8d. per quarter in 1873, to 29s. 9d. in 1889, or a reduction in the price of food equal to 47·51 per cent. in seventeen years. Therefore, the greater number of hands placed upon the land to produce a definite and necessary quantity of food products, the greater is the amount of useless or wasteful and unproductive labour. At the present moment it is the most uncivilised and most miserable populations which relatively employ

* Within the wonderful reign of our Gracious Queen Victoria the days labour-time, *per se*, in England has been reduced about 25 per cent., while the wages of labour has, on the average, increased by 50 per cent.

the larger proportion of breadwinners upon the land. It is the country which relatively places the smallest number of hands on the land for the production of food and raw products which has also attained the highest stage of progress, and secures for each breadwinner the largest purchasing power, and, therefore, the largest amount of satisfactions. I deny, therefore, most emphatically that whatever distress in the United Kingdom still exists would be lessened by any scheme which would place more hands on the land than its economic conditions demand for the production of food and raw products.

It would be an economic blunder, producing a waste of human effort, and so increasing tenfold the miseries it proposes to remove. If two men were set on the land to do all the work necessary which one properly equipped labourer can accomplish, it would at one stroke reduce the productive power over real utilities (for to produce more than is reasonably wanted of any good thing would not be a utility) by about 31 per cent., and a corresponding decrease of the average purchasing power of the labourer.

Provision for the present distress of the pauper and unemployed at most only diminishes the purchasing power of breadwinners by $2\frac{1}{2}$ per cent. Noble as are the ideals of the better class of socialistic writers, I am, nevertheless, convinced that the selfishness of landlordism or capitalist is not the cause of our miseries, and that placing more people on the land than the economic conditions of the particular country requires would, instead of removing the present evils, increase them tenfold. The misery caused by loss of health, death of the breadwinner, idleness, improvidence and vice, cannot be removed by opening the land by any increase of facilities. The congestion of labour, so called, in crowded centres is not due to such a cause at all. It is entirely due to the lack of knowledge how to allocate the bread-winner each day added to the population in accordance with the exact division of labour in which fresh services are required.

The broad proportions which at present are required within a complete circle of exchange of services are as follows:—Agricultural and pastoral services, 52·5 per cent.; industrial services, 30·1 per cent.; domestic, 6·8 per cent.; commercial services, 5·2 per cent.; professional and undefined services, 5·4 per cent.; total, 100 per cent.

These proportions vary with the economic conditions of the locality, and with every change in the modes of production caused by improvements in machinery or the introduction of new auxiliary forces. But whatever local proportions may be requisite, it is true that congestion of labour and consequent distress are nearly all due to unconscious transgression of the law which determines divisions of labour to be in exact accord with the nature and proportion of products or satisfactions in common demand.

It is largely due to the flooding of particular kinds of employment beyond the strict proportion which local wants demand, that inconvenience or distress is felt in young as well as old countries; and, thus, applicants for a given kind of employment may often fail, not necessarily because there is no room for more labour, but because the direction in which the applicant has been trained, or in which they desire so be employed, is out of harmony with the natural or local proportions of that particular service engaged in the production of general requirements or satisfactions. What is needed, therefore, is something like omniscience, to continually devise and regulate the training of breadwinners in the proportions in which their services will be in demand. We must not, therefore, despise the defective machinery—capitalists and organisers of industry—which hitherto have performed roughly this grand service for us. At least we owe them so much that we cannot desire to see them removed until it can be clearly shown that a better provision can take their place.

ECONOMIC SCIENCE PAPERS.

No. 1.—DEMOCRACY AND THE VOICE OF HISTORY.

By W. Jethro Brown, M.A., LL.D.

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

The solution of a political problem required two qualifications: a mind disciplined in the process of correct thinking, and a knowledge of the particular factors of the problem requiring solution. The study of history went far to achieve the latter object, both by affording the student historical parallels in the light of which he might understand his factors, if not predict the results of their combination, and by showing how the particular conditions and forces of our time had acquired their present character. While the value of an acquaintance with the processes of development was generally admitted, there was a very common tendency to decry the value of historical parallels on the plea of the changed conditions of modern society. It was a special object of the paper to discuss the precise limits within which this scepticism was justified. Possible analogies from Grecian and Roman history were quoted, with the object of ascertaining whether it would be

possible to adduce any legitimate conclusion with regard to the modern problems of capital and democracy. Apart from the utility of historical study as a means of throwing light upon particular problems, there was its undoubted value as a mental and moral training. Looked at from this point of view, history offered a singularly powerful remedy for some of the most serious evils of democratic government. Intellectually, it contributed a knowledge of social laws and a mental discipline of peculiar value to the political student. Morally, it might go far to lessen the evils of popular indifference, the dogmatism which resulted from a restricted vision or a deficient political sympathy, and that unappreciation of the claims of superior merit, which was so largely responsible for present standards of legislation.

No. 2.—THE PRACTICAL APPLICATION OF ECONOMICS.

(*Illustrated by Diagrams.*)

By Alfred De Lissa.

(*Read Tuesday*, 11 *January*, 1898.)

[*Abstract, omitting Diagrams.*]

If political economy is to be of any material service, it should, where possible to do so, establish, as in other sciences, a theory, or at least a working hypothesis, as the basis of deduction ; and also of such action as can be taken to carry out the objects with which the science is concerned. Until this is accomplished there can be no material progress. There was none in chemistry until the discovery by Dalton of the atomic theory, deduced from the observation of chemical combination in multiple proportions ; nor in astronomy, until the discovery of Newton's theory of gravitation, the basis of the science.

In my paper on the Organisation of Industry, read at the Hobart meeting of this Association in the year 1892, published *in extenso* in the volume of proceedings for that year, I presented the indication of a law, ascertained for the English speaking countries, for which statistics were available, and its further consideration has led me to some very definite results.

I stated that law, as it then occurred to me to formulate it, to be, that the expenditure in any one of those countries of the

proceeds of its production give to the classes in the community whose employments consist in services, incomes equivalent to the wages and profits of those engaged in the work of production.

Professor Sidgwick has emphasised the consideration which is to be given to the work of services not engaged in the work of production, in an inquiry respecting production, distribution, and wealth.

No theory has so far, however, been enunciated which would establish definite data as to the measure of wealth generally of a specific production, or of production under different conditions, or which could be designated as a law of distribution.

The question is solved by ascertaining in any country the ratio of expenditure out of aggregate earnings for material products at their original value, at the point of production. Anything paid in excess for the product represents services such as those of transportation or distribution. In the paper referred to, I pointed out that the money proceeds of production expended in the country, which necessarily represent the product, give incomes or earnings, in circulation through different hands, without the consumption of the amount of product the currency represents; and according to a hypothesis I then presented, that the aggregate of the secondary incomes received was governed by the law of a geometrical progression. The operation can be stated as one which must have universal application, according to the ratio which is ascertained. My deduction from the statistical information then available, was that the ratio of such expenditure in the aggregate, was one-half—that is to say, that taking all classes in the community, those in receipt of the highest and the lowest incomes, there would be that definite ratio.

But the establishment of the theory or working hypothesis I have in mind, would not depend upon the question whether the statistical data or my deduction of the ratio were correct; because if it should appear that for any particular country the ratio were not 50 per cent., or a sufficiently close approximation thereto, to be so stated, the ratio of expenditure, whatever it might be, would nevertheless be attended with results of a corresponding character. I am indebted to Professor Gurney of the Sydney University for the form of the calculation which would give the result of any progression based upon my hypothesis, from which I have been able to frame the following formula which such calculation indicates.

$$\frac{\text{V (value of production)}}{\text{R (ratio of expenditure)}} = \text{I (total incomes).}$$

To show the operation of the law, I give results varying from the ratio of one half, thus—

The total production being 100.

If the ratio of expenditure should be one half, as I have found it to be, then

$$\frac{100}{\frac{1}{2}} = 200 \text{ total incomes} = \text{incomes of } 100 \text{ for services.}$$

If the ratio of expenditure should be $\frac{2}{5}$, then

$$\frac{100}{\frac{2}{5}} = 250 \text{ total incomes} = \text{incomes of } 150 \text{ for services.}$$

If the ratio of expenditure should be $\frac{1}{4}$, then

$$\frac{100}{\frac{1}{4}} = 400 \text{ total incomes} = 300 \text{ incomes for services.}$$

If the ratio of expenditure should be $\frac{1}{8}$, then

$$\frac{100}{\frac{1}{8}} = 800 \text{ total incomes} = 700 \text{ incomes for services.}$$

If the ratio of expenditure shold be $\frac{3}{5}$, then

$$\frac{100}{\frac{3}{5}} = 166{\cdot}6 \text{ total incomes} = 66{\cdot}6 \text{ for services.}$$

I have been led to express the hypothesis of the operation of expenditure somewhat differently to that stated in my previous paper, tending to show that the increase of the incomes must take place in a geometrical progression according to the ratio. Referring to the diagrams of that paper, I considered the result of the total expenditure of the primary workers in the aggregate. Although the total expenditure served the purpose of illustration, it need not be taken. When it is considered that any amount expended by the primary workers in the aggregate, and therefore entering into general circulation, will be received by large numbers of all conditions amongst the different groups of workers, it appears manifest that expenditure in the aggregate of the amount received at any time according to the same ratio will give the like result.

I have also found that it is immaterial, as regards the result of expenditure, whether the proceeds of production expended by those of production in the land, or of that from a foreign source entering the country as income or capital.

It must, I contend, be admitted as a theory or working hypothesis of the science, as regards distribution, that the total incomes of all classes in a country derived from the expenditure of the proceeds of its production, will depend upon the ratio of expenditure in the aggregate for material products, as indicated by the formula stated.

$$\frac{\text{V (value of product)}}{\text{R (ratio of expenditure)}} = \text{I (total incomes).}$$

And as a corollary: That the incomes of secondary workers, or those not engaged in the primary work of production, will depend

upon the expenditure in the country of the proceeds of its production, or the expenditure otherwise than in the work of production, of incomes from abroad, as indicated by the formula stated.

The following will be corollaries as regards production :—

(1.) That where the ratio of expenditure for services is one-half, the production stimulated by any new or additional industry in a country will be a corresponding additional production.

(2.) That where the ratio of expenditure for services is more than one-half, the production so stimulated will be diminished in the like ratio.

(3.) And where the ratio of expenditure for services is less than one-half, the production so stimulated will increase in the like ratio.

(4.) That of the lesser ratio, or a greater expenditure for services, represents a higher civilisation, increasing in geometrical progression with the ratio.

(5.) That of the greater ratio, or a lower expenditure for services, represents a lower civilisation, decreasing in geometrical progression with the ratio.

Thus—production 100 and ratio (less than $\frac{1}{2}$) $\frac{2}{5}$ gives $\frac{100}{\frac{2}{5}}$, 250 total incomes = 150 for services, and the additional production stimulated or required to feed workers will be 66·6.

If the ratio be (more than $\frac{1}{2}$) $\frac{3}{5}$, production 100 gives $\frac{100}{\frac{3}{5}}$ = 166·6 total incomes = 66·6 for services, and the additional production required to feed workers will be 150.

I referred in my paper, read at the Hobart meeting of the Association, to Quesnay's "Tableau Economique" having been considered as lost, or, at all events, that one or two copies only existed in some European libraries; and to the statement in Mr. M'Gullock's introduction to Adam Smith's "Wealth of Nations" that the "Tableau Economique" was a formula constructed by Quesnay to exhibit the various phenomena attendant upon the production of wealth and its distribution. The formula of the table did not, so far as I have been able to ascertain, find its way into the works of any of the known English economists. In the month of December, 1894, a *fac simile* of the first edition of the "Tableau" was published by the British Economic Association, the same having been discovered by Dr. Bauer among the papers of the elder Mirabeau; and the journal of the Association for March, 1895, contains an article by Dr. Bauer dealing with the table. It is of service in connection with the subject of present inquiry.

Upon a first glance at the "Tableau" it appeared to me that it had anticipated the deduction of a law such as that I have stated, and that the formula which I have presented in Diagram 2 reproduces the table in another form. This is not, however, the case, although the appearance is very deceptive. The "Tableau" does not show any increase of incomes in the so-called non-productive class (3), the duplication of such portion of their incomes which is shown being only incident to the exchange with the primary workers, which would result in the 15 shown in my original diagram—that is to say, the circulation of the currency for services yielding income among the secondary workers themselves has not, and necessarily could not, have been considered. It will be seen that the series of incomes shown in the first perpendicular column on the right in Class 3 of the "Tableau" are received from different sources of production or new producers. Each of such incomes have expended one-half for product, retaining one-half of the currency received, which the text states is expended in the class itself in which all manufactures are included, the latter statement as to the expenditure being also made as to the currency of 300 remaining in Class 1.

The value to a country of the different kinds of production may be stated as follows, commencing with those of lowest value, and, assuming the proportion of raw material to be 50 per cent.,—

(1.) New production in manufacturing industry, previously the subject of international interchange, in which the raw material is not produced in the country nor any additional production in exchange for it. For every £100 worth of manufactures so produced there will, according to the ratio which I have indicated, be increased earnings at least to the amount of £50 by primary workers, and £50 by secondary workers.

(2.) A new production in manufacturing industry, previously the subject of international interchange, in which the raw material or a new production of raw material to be given in exchange for it is produced in the country. In this case, for every £100 of manufactures so produced, there will be increased earnings at least to the amount of £100 by primary workers and £100 by secondary workers.

(3.) The production of a new raw material for which there is a constant market in other countries.

This will be a greater source of wealth.

Australia is said to be particularly adapted for sericulture. The grain or worm has been found to be entirely free from the disease which exists in other countries, and at one time threatened the extinction of the industry. In this case, if the industry were established, for every £100 worth of the product, minus the raw material used in its production, which should be but fractional,

there would be increased earnings to the amount of £400, £100 in the production and £100 in an additional production with the corresponding secondary incomes of the like amounts.

(4.) The new production in a country of some article of invention or utility not in use before.

The result in the production and distribution of wealth may then be considered still greater, for there is in such a case a new source of wealth, in addition to all other available resources which it may be possible to utilise.

Take for instance the manufacture or production of bicycles in a manufacturing country like the United States, where the whole of the raw material, or the whole with but a fractional portion will be manufactured, as well as the article itself. There is an addition to the wealth of the country, primarily, of the whole value of the production, except so far as some other industry is not displaced by the new utility, and the large expenditure in the country for the purchase of bicycles will not diminish the funds previously available for other expenditure. The new industry will promote an additional production of general products to the like amount, and the circulation of the wages and profits will give four incomes, each the value of the production; in addition, in the first instance, to the expenditure of capital for the construction of plant, which is generally one million for each million of annual production, and also the additional production which it will stimulate, and the secondary incomes, incident to both of such latter productions. There might also be an expenditure of capital for the erection of factories, in a new manufacturing industry, of three-fourths of a million, the general estimate for each million of production; with the like results as to an additional production and secondary incomes. In the case of the individual, it may be that some other expenditure will be curtailed; but, taking the community in the aggregate, the funds for expenditure will be increased. It is otherwise in Australia where the bicycle is not manufactured; the funds available in the aggregate for expenditure will be lessened by the amount paid for purchases. There will be some decreased earnings by those employed in other means of locomotion for the conveyance of passengers, or engaged in the breeding or care of horses, in the cultivation of pasturage and the procurement of fodder for the lesser number of horses employed; but this will be very fractional in a manufacturing country which derives increased wealth, not only from the internal trade, but also from the supply of foreign markets. This increase of wealth in a country like the United States or England must be very great. I am not aware if figures are available in respect to this particular industry. I find a statement in the *Scientific American* for 1896 that over sixty million dollars (£12,000,000)

are invested in plant in the United States, and that the industry gives employment to an army of industrial workers no less than 70,000.

A similar result must attend the construction and maintenance of the telephone.

It may be stated, as an economic axiom, that the progress of invention furnishing a new utility for which there will be a demand, increases the wealth of the community to the value of the earnings derived from the production of that utility (except so far as other industries may be displaced), without any decreased expenditure in the aggregate by the purchases made for the new utility in the country in which the same is produced.

It will be noted that, for the operations incident to a new production of 100, a circulating capital of 100 is required. The aggregate amount which has represented circulating capital throughout the year, in the illustration given by one of the diagrams, is 600, and the total production in connection with the industry is 1,200. A circulating capital of 100, therefore, suffices for the two productions—the original one and the additional production stimulated. This circulation enables us to ascertain precisely the circulating capital which is in existence in the country, or which must be available in case of a new industry. The amount which represents the total of the circulating capital in use throughout the year must be the sum to represent one half of the balance of all production, after deducting the increased value—that is to say, the profits, less an amount representing the approximate expenditure of the employers.

The whole amount of circulating capital required may not of course be in existence at the same time, its production and reproduction is constantly going on.

Total production in New South Wales for the year 1892 was ascertained at £35,289,000. The table of private wealth for the year shows the value of merchandise at £15,585,000. Quoting from Coghlan, "this represents the value of the goods and stocks of all kinds, whether in store or shops, or at the place of production, and averages in value half the imports and exports taken together." The value of stock for the year slaughtered was £4,450,000, a total of £20,035,000. Allowing for savings as stated for other years approximately £3,000,000, a little more or less, the balance approximating £17,000,000 would represent the amount of circulating capital which would be employed throughout the year. Commencing any of the diagrams presented showing production, with capital £17,500,000, the same would result in a total production of £35,000,000.

When works of construction have taken place in a country by means of borrowed capital, upon which interest has to be paid, products being sent away annually in payment of the interest; if

such works of construction are not reproductive, or when money is borrowed to meet a deficiency in public revenue, the actual payment by the country, having regard to its true wealth, is not represented by the current rate of interest paid on the loan.

If the work of construction is not reproductive, every £100 of product sent away for interest, which would have been otherwise employed, represents two incomes of the like amount, which would have been the result of the employment. The cost to the real wealth of the country is double the rate of interest paid. Where the work is reproductive, yielding interest at the same rate as that which is paid, such interest represents the circulating capital employed in the procurement each year of the product which is sent away.

It cannot be doubted that the more a country is self-contained, and the larger the number of industries which can be carried on, without detriment to others by the means employed, the wider the markets, the larger in number the avenues of employment, and the greater must be the wealth in the aggregate earnings which constitute prosperity. The culture of its people will also be greater in the variety of occupation, adapted to the ability and intelligence of all capacities, and stimulating the exercise of inventive faculties and artistic skill. The real wealth of a country is not indicated by the value of its production, if the whole proceeds are not retained ; and, in considering its wealth, the figures of foreign indebtedness must always be set against the figures of production. Neither is the wealth of a country indicated by the value of imports and exports representing its external trade.

If my deductions are correct, except as to the share to be received by wage earners in particular industries, there is in a country which is self-contained a natural distribution of the proceeds of production against all classes. They are diffused equally among those engaged in the work of primary industry, and among all other groups of workers, each class, and the individuals in each class, receiving portion of the proceeds according to the demands for their employment. The interest of any one producing class is the interest of all. The strike which paralyses industry for a time, and impairs a market, is the concern of all. As I contended in my previous paper, agencies must ultimately be evolved, by which the shares of the product received by the employer, and the mechanic or labourer, engaged in the work of production, the subject of frequent contests now, may be satisfactorily adjusted, and the evils of monopolies or trusts prevented. These are the vital objects to which the thoughts of those concerned in promoting progress should be especially directed. The importance of the aid which the organisation of government can give in promoting the development of industry and the increase of production in new lands, whose resources are greatly unde-

veloped, must be manifest from the foregoing considerations; and the principle must be recognised that the sources of production should not be held profitless. Much may be done by the Statistical Department in every country to ascertain requirements, and to control by the intelligence which it can exercise. It will yet be admitted that political economy is a science, able, like other sciences, to trace the operation of law amid agencies apparently fortuitous, and to serve as a guide to action which may achieve the highest and best results.

No. 3.—THE ADVANTAGES OF A FEDERAL UNION.

By W. Jethro Brown, M.A., LL.D.

(Read Tuesday, 11 January, 1898.)

The object of this paper was to show the precise advantages which might be expected to follow the federation of the Australian Colonies. Union must tend to insure our peace, promote our prosperity, and advance our honor. It ensured peace in the internal affairs of the separate colonies, since the difficulties of insurrection were increased when it was necessary to arouse the citizens of a Commonwealth; it ensured peace between colony and colony, by submitting all disputes to the peaceful arbitration of a common authority; it ensured peace in our foreign relations by increasing the respect of foreign States, and by securing a more wise and consistent foreign policy. So, too, federation must tend to promote our prosperity. It was clearly desirable, in the management of State affairs, that no more force should be applied to desired ends than was absolutely necessary; that yet sufficient force must be applied, and that the force must be carefully exerted in the right direction. Each of these principles was violated in our present state of disunion. The most forcible illustrations of this fact could be found in the spheres of production and exchange. Finally, federation must tend to advance our honor. No student of Australian politics could fail to observe the commonness of tone in political life, and the excessively provincial character of our political ideas. Such defects were proving a serious menace to our future, and it was not perhaps too much to hope that they might be overcome under the inspiring influence of a new national ideal. With respect to the Commonwealth Bill, there were necessarily many questions for

discussion, and it was incredible that the settlement of each and every one of these questions should be effected in such a way sa to satisfy the ideal of any one man. Probably, in view of the fallibility of the individual, a persuasion of the perfection of the Bill might arouse the suspicion of the impartial. If, therefore, any individual would delay federation until he could approve of the Bill in every particular, his position must be described as one of uncompromising hostility. The true federalist would recognise the absurdity of insisting upon a condition so unwise, and praise or condemn by reference to a broad and impartial view of the Bill as a whole. There were many, and these perhaps not the least wise, who would prefer the judgment of the present Convention to their own, and therefore undertake to vote for such a Bill as might have received its final sanction. The advantages of federal union were obvious; the constitutional questions involved in the Commonwealth Bill were complicated and difficult, and required for their discussion and settlement the experience, the skill, and the wisdom of a select assembly. It would seem, therefore, not unwise in a citizen assured of the advantages of federation to entrust the solution of constitutional difficulties to the capacity of the Federal Convention. Never in the history of these colonies was there so apt an occasion for the display of a generous confidence. If we failed in that confidence we condemned our own selection, and asserted the incapacity of future generations to remedy the particular evils which subsequent experiences might reveal.

No. 4.—FEDERATION AND RESPONSIBLE GOVERNMENT.

By A. B. Piddington, B.A., M.L.A.

(Read Tuesday, 11 January, 1898.)

No. 5.—SOME THOUGHTS ON SOCIAL EVOLUTION.

By Rev. Canon Corlette, D.D.

(Read Wednesday, 12 January, 1898.)

No. 6.—CRIMINAL RESPONSIBILITY: A CHAPTER FROM A CRIMINAL CODE.

By Sir SAMUEL W. GRIFFITH, G.C.M.G., M.A.,
Chief Justice of Queensland.

(*Read Wednesday*, 12 *January*, 1898.)

THERE are, no doubt, reasons for the apparent reluctance of Great Britain and the Australian Colonies to attempt to formulate their laws in a scientific form—reasons, however, which, good or bad, do not seem to operate in the minds of the people of other civilised States. Probably, one main reason is a conservative instinct, which seems to dread a formal change even more than a radical alteration in the law, and which is, perhaps, most frequently observed in members of the legal profession, without whose assistance a scientific formulation of the law is usually impracticable. Possibly, also, a want of confidence on the part of the lawyers, either in themselves or in one another, operates in the same direction. There is also the real or supposed difficulty of inducing a Legislature to accept a complicated law dealing with subjects with which the legislators are unfamiliar. This last difficulty is, however, often greater in anticipation than in reality.

Three branches of the law have lately been reduced to the form of a code in Great Britain—the law of Bills of Exchange, the law of Partnership, and the law relating to the Sale of Goods; and the English codes on these subjects have been adopted by most, if not all, of the Australian Colonies. The law of Defamation has been codified in Queensland, and the code has been adopted by Tasmania; but the branch of the law which is of most general application, and most nearly affects the largest number of people, still remains uncodified.

In 1880 a Bill was introduced in the House of Commons, based upon a Draft Code of Criminal Law prepared by Lord Blackburn, Mr. Justice Barry, of Ireland, Mr. Justice Lush, and Sir James Fitzjames Stephen, but it was not proceeded with; and since then nothing seems to have been done in England for the codification of the Criminal Law. The Parliament of New Zealand, however, in 1893 adopted the English Bill of 1880 with unimportant modifications. That Bill was open to serious criticism, and it is, perhaps, not to be regretted that it did not become law in England.

There seems to be much misunderstanding as to the nature and effect of codification. Chief Justice Cockburn described the work of codifying the Criminal Law in the following terms:—"So

great and difficult a work as that of stating the Criminal Law in all its voluminous details, with a due regard to arrangement and classification, in language carefully selected, avoiding, on the one hand, the cumbrous, prolix, inartificial, and bewildering phraseology of our Statutes; and, on the other, taking care that the terms used shall be sufficiently comprehensive to embrace every case which is intended to come within it."—(Letter to Attorney-General, 12th June, 1879.) This may be accepted as a sufficiently exacting definition of a perfect code. The most common objection to the codification of the criminal law is that such a task cannot be perfectly performed; that there will certainly be omissions; that under the present system the Judges can from time to time "declare" the common law in such a way as to cover new developments of lawlessness; and that, as by codification these powers are taken away, there would be a loss of the "elasticity" of the common law. The practical difference between such a power of "declaring" the law and a power of legislation is very little. But this power is in practice very rarely, if ever, exercised; and an even tolerably well-drawn code would not fail to include all the principles and rules on which the supposed new declarations or adaptations are founded; and, if any were omitted, they could be added by the Legislature with all the more ease and certainty if they had an otherwise complete statement of the law before them.

It should be remarked that codification is a very different thing from consolidation. The latter is a comparatively easy though laborious work, consisting merely in the collection and orderly arrangement of existing statutory provisions. Codification includes all this, but includes also a complete statement of all the principles and rules of law applicable to the subject matter. As an illustration of this part of the work of codification, it is proposed to refer to the chapter on Criminal Responsibility contained in the Draft Code lately prepared by the writer for the Government of Queensland. This branch of the criminal law is substantially common to all civilised systems, and is of general application with regard to all acts alleged to be criminal.

The chapter (*a*) begins with the rule sometimes expressed in the maxim, "*Ignorantia juris neminem excusat*," which is thus formulated:—

"IGNORANCE OF LAW.

"24. Ignorance of the law does not afford any excuse for an act or omission which would otherwise constitute an offence, unless knowledge of the law by the offender is expressly declared to be an element of the offence."

(*a*) Chapter v.

The qualification (which is not usually expressed) is or may be necessary. For instance, the misapplication of funds by members of local authorities is in Queensland an offence only when the misapplication is known by the offender to be contrary to law.

The next rule is that intended to be expressed by the maxim, "*Actus non facit reum nisi mens sit rea.*"

"INTENTION: MOTIVE: BONA FIDE CLAIM OF RIGHT.

"25. Subject to the express provisions of this code relating to negligent acts and omissions, a person is not criminally responsible for an act or omission which occurs independently of the exercise of his will, or for an event which occurs by accident.

"The result intended to be caused by an act or omission is immaterial, unless the intention to cause a particular result is expressly declared to be an element of the offence constituted, in whole or part, by the act or omission.

"Unless otherwise expressly declared, the motive by which a person is induced to do or omit to do an act, or to form an intention, is immaterial so far as regards criminal responsibility.

"A person is not criminally responsible, as for as an offence relating to property, for an act done or omitted to be done by him with respect to any property in the exercise of an honest claim of right and without intention to defraud."

The first branch of the section corresponds to Article 45 of the Italian Penal Code of 1888 (the latest and best of penal codes), which provides that a man cannot be punished for an offence (*delitto*): *Se non abbia voluto il fatto che lo costituisce.* I do not know of any English word in common use corresponding to the sense in which the word *voluto* is here used; but the paraphrase, "occurs independently of the exercise of his will," expresses precisely the same idea.

Much confusion has arisen in law from the inaccurate use of the words "intention" and "motive," which are often treated as synonymous. The true rule is, it is apprehended, as stated in the text. The motive by which a man is induced to form the intention to kill another may be very material as a guide to a jury in a case of circumstantial evidence: but it is quite a different thing from the "intention" with which the fatal blow is struck.

The rule as to mistake of fact is thus expressed:—

"MISTAKE OF FACT.

"26. A person who does or omits to do an act under an honest and reasonable, but mistaken, belief in the existence of any state of things is not criminally responsible for the act or omission to any greater extent than if the real state of things had been such as he believed to exist.

"The operation of this rule may be excluded by the express or implied provisions of the law relating to the subject."

As to this, there is probably no room for doubt.

The next rule (which, it is believed, is not to be found in any of the books) deals with extraordinary emergencies :—

"EXTRAORDINARY EMERGENCIES.

"27. Subject to the express provisions of this code relating to acts done upon compulsion or provocation or in self-defence, a person is not criminally responsible for an act or omission done or made under such circumstances of sudden or extraordinary emergency that an ordinary person possessing ordinary power of self-control could not reasonably be expected to act otherwise."

On this section it may be remarked that it gives effect to the principle that no man is expected (for the purposes of Criminal Law, at all events) to be wiser or better than all mankind. It is conceived that this is a rule of the Common Law, as it undoubtedly is a rule upon which any jury would desire to act. It may, perhaps, be said that it sums up nearly all the Common Law rules as to excuses for an act which is *primâ facie* criminal.

The exceptions as to compulsion, provocation, and self-defence are necessary, because there are positive and definite rules dealing with these cases, which may be regarded as requiring exceptional treatment.

Then follow the rules as to insanity and intoxication :—

"PRESUMPTION OF SANITY.

"28. Every person is presumed to be of sound mind, and to have been of sound mind at any time which comes in question, until the contrary is proved.

"INSANITY.

"29. A person is not criminally responsible for an act or omission if at the time of doing the act or making the omission he is in such a state of mental disease or natural mental infirmity as to deprive him of capacity to understand what he is doing, or of capacity to control his actions, or of capacity to know that he ought not to do the act or make the omission.

"A person whose mind, at the time of his doing or omitting to do an act, is affected by the delusions on some specific matter or matters, but who is not otherwise entitled to the benefit of the foregoing provisions of this section, is criminally responsible for the act or omission to the same extent as if the real state of things had been such as he was induced by the delusions to believe to exist.

"INTOXICATION.

"30. The provisions of the last preceding section apply to the case of a person whose mind is disordered by unintentional intoxication or stupefaction caused by drugs or intoxicating liquor or any other cause.

"They do not apply to the case of a person who has intentionally caused himself to become intoxicated or stupefied in order to the commission of an offence, whether the offence with which he is charged or not, or in order to afford excuse for the commission of an offence.

"When an intention to cause a specific result is an element of an offence, intoxication, whether complete or partial, and whether intentional or unintentional, may be regarded for the purpose of ascertaining whether such an intention in fact existed."

There is, perhaps, no branch of the criminal law which has given rise to more discussion and difference of opinion than the relation of mental infirmity to criminal responsibility. The rule of the Common Law is generally thus stated: "Every man is presumed to be sane until the contrary is proved: To establish a defence on the ground of insanity it must be clearly proved that at the time of committing the act the accused was labouring under such a defect of reason, from disease of the mind, as not to know the nature and quality of the act he was doing, or, if he did know it, that he did not know he was doing what was wrong."

These are the terms in which the rule is expressed in the answers given by the Judges to the House of Lords in McNaghten's case (10 Cl. and F. 200). In that case, however, the real question was as to the proper rule for judging of the criminal responsibility of a man labouring under specific delusions, but otherwise of sound mind, and the learned Judges prefaced their answers by pointing out that they assumed that the questions put to them by the House of Lords were confined to such persons.

The language of the learned Judges has been much criticised. Lord Chief Justice Cockburn said: "What is meant by the nature and quality of the act I really do not know. Does it simply mean that the person committing the act knew what he was doing, or that he knew that the act was legally wrong or was morally wrong? What is meant by the alternative 'or that the act was wrong'? Is this phrase meant to be synonymous with the 'quality' of the act as just before mentioned? If not, what is the difference between the two forms of expression?"—(Letter to Attorney-General, 12th June, 1879, p 15.) In practice every Judge amplifies the rule by telling the jury what in his opinion is meant by the 'nature and quality' of the act.

The subject has been much considered by the Continental nations of Europe. Before referring to the particular provisions of their codes it may be desirable to offer a few observations on the general principles applicable to the matter. An act to involve criminal responsibility must be voluntary, as distinguished from involuntary (s. 25)—that is to say, it must be accompanied by volition. In order that an action may be accompanied by volition there must be in the first place perception, more or less accurate, of the facts, then a determination or choice of the action to be taken upon those facts, and finally the action. If the person in question is incapable, from mental disorder, of rightly perceiving the facts, he should be treated on the same footing as a man who in good faith misapprehends the facts (s. 26). If he is for the same cause incapable of exercising the power of determination or choice, he should be treated on the same footing as a man who does an act independently of the exercise of his will (s. 25). So far there is little reason for controversy. But it is conceived that our law assumes the notion of duty. No one supposes that everyone or anyone knows all the provisions of the criminal law. Yet no one above the age of discretion (s. 31) is excused by ignorance of law (s. 24). Why is the distinction drawn at a particular age? Not, surely, because at that age knowledge of the law comes to a child, but because he is then supposed to be capable of knowing that some things ought not to be done—*i.e.*, of apprehending the idea of duty. If this is so, there is a third element of criminal responsibility corresponding to the capacity of a child who has reached the age of discretion; and a person who, by reason of mental disorder, is in the condition of a child as to capacity of apprehending the notion of duty, ought to be equally free from criminal responsibility. This last element seems to be wanting in the definition of insanity given in the Continental codes, but it is, probably, part of the law of England.

The following statements of the definition of insanity given in the various Continental codes and draft codes are taken from the Ministerial explanation made by Signor Zanardelli in introducing the Italian Penal Code to the Legislature in 1888. (The definition in the Draft Code as introduced was as follows :—" A person is not punishable who, at the moment when he committed the act, was in such a state of defect or morbid affection (*alterazione*) of the mind as to deprive him of consciousness of his acts or of the possibility of acting otherwise.")

Dutch Code : ‘ Incomplete development or morbid disturbance of the intelligence.’

German Code : ‘ Deprivation of understanding or condition of morbid affection of the mental faculties.’

Hungarian Code : ‘ State of unconsciousness or disturbance of the intellectual faculties.’

Code of Zurich: 'If the faculties of the mind of the accused were overturned in such a manner as not to possess the attitude of free determination or the discernment necessary to understand the criminal nature of the act.'

Austrian Draft of 1881: 'State of want of understanding or of deficient development or disturbance of the intellectual faculties.'

Russian Draft of 1881: 'Insufficiency of the intellectual faculties, or morbid disturbance of the activity of the mind (*spirito*), or state of unconsciousness.'

The definition actually adopted in the Italian Code may be thus translated: 'Such a state of infirmity of mind (*mente*) as to deprive him of consciousness of his act or of freedom of action.' (s. 46).

The definition given in section 29, above, is substantially the same as this, with the addition of the element of moral capacity.

The New York Code, as amended in 1882, adopts the words of the Judges in McNaghten's case.

The Code Napoleon, which was enacted before the subject had been so fully considered as it has been of late years, puts insanity and compulsion together. 'It is neither crime nor misdemeanour (*délit*) when the accused person was in a state of insanity (*démence*) at the time of the act, or if he was constrained by a force which he could not resist.' (Code Pénal, Art. 64.)

Any direction to a jury which omitted a reference to any one of the three elements—capacity of perception, capacity of choice, and moral capacity—in a case in which such an element was material would, probably, be contrary to Common Law. As to the reasonableness of the rule, as stated in section 29, there is little room for doubt. A moment's consideration will suggest cases in which any two of the three elements may be present, while the third is absent, and in which it would be absurd to hold the actor criminally responsible. It is important to remember, however, that the absence of either capacity is immaterial, unless it arises from mental disorder or infirmity.

It will be observed that the rule stated in section 29, considered from the points of view to which attention has been invited, is merely a particular instance of the application of the general rules determining the question of criminal responsibility stated in ss. 25, 26, and 31.

The second paragraph of the section embodies the opinion of the Judges on the question actually submitted to them in McNaghten's case.

Othe provisions of the chapter are as follows:—

"IMMATURE AGE.

"31. A person under the age of 7 years is not criminally responsible for any act or omission.

"A person under the age of 14 years is not criminally responsible for an act or omission, unless it is proved that at the time of doing the act or making the omission he had capacity to know that he ought not to do the act or make the omission."

"JUDICIAL OFFICERS.

"32. Except as expressly provided by this code, a judicial officer is not criminally responsible for anything done or omitted to be done by him in the exercise of his judicial functions, although the act done is in excess of his judicial authority, or although he is bound to do the act omitted to be done.

"JUSTIFICATION AND EXCUSE: COMPULSION.

"33. A person is not criminally responsible for an act or omission, if he does or omits to do the act under any of the following circumstances, that is to say—

"(1) In execution of the law;

"(2) In obedience to the order of a competent authority which he is bound by law to obey, unless the order is manifestly unlawful;

"(3) When the act is reasonably necessary in order to resist actual and unlawful violence threatened to him, or in his presence to another person who is under his immediate care, or to whom he stands in a conjugal, parental, filial, or fraternal relation, or in the relation of master or servant;

"(4) When he does or omits to do the act in order to save himself from immediate death or grievous bodily harm threatened to be inflicted upon him by some person actually present and in a position to execute the threats, and believing himself to be unable otherwise to escape the carrying of the threats into execution:

But this protection does not extend to an act or omission which would constitute an offence punishable with death, or an offence of which actual danger to the life or grievous bodily harm to the person of another, or an intention to cause such danger or harm, is an element, nor to a person who has by entering into an unlawfnl association or conspiracy rendered himself liable to have such threats made to him.

"Whether an order is or is not manifestly unlawful is a question of law.

"COMPULSION OF HUSBAND.

"34. A married woman is not free from criminal responsibility for doing or omitting to do an act merely because the act or omission takes place in the presence of her husband.

"But a married woman is not criminally responsible for doing or omitting to do an act which she is actually compelled by her husband to do or omit to do, and which is done or omitted to be done in his presence, except in the case of an act or omission which would constitute an offence punishable with death, or an offence of which actual danger to the life or grievous bodily harm to the person of another, or an intention to cause such danger or harm, is an element, in which case the presence of her husband is immaterial."

"LIABILITY OF HUSBAND AND WIFE FOR OFFENCES COMMITTED BY EITHER WITH RESPECT TO THE OTHER'S PROPERTY.

"37. When a husband and wife are living together neither of them incurs any criminal responsibility for doing or omitting to do any act with respect to the property of the other, except in the case of an act or omission of which an intention to injure or defraud some other person is an element, and except in the case of an act done by either of them when leaving or deserting, or when about to leave or desert, the other.

"Subject to the foregoing provisions a husband and wife are, each of them, criminally responsible for any act done by him or her with respect to the property of the other, which would be an offence if they were not husband and wife, and to the same extent as if they were not husband and wife.

"But neither of them can institute criminal proceedings against the other while they are living together."

The provisions of sections 33 and 34 are probably not quite in accord with the existing law, which is, however, obscure. Section 34, it will be noticed, treats the case of a wife as an instance of the general law as to compulsion.

Section 37 expresses the existing law of Queensland and England so far as regards the husband. It is not easy to see why the same rules should not apply to the wife.

This branch of the criminal law has been taken as an illustration of the nature of the work of codification, because, as already suggested, it is of the widest application, and embodies rules which, for the most part, are not peculiar to any locality or any special system of jurisprudence; because the question whether these rules are good or bad depends upon general principles of which laymen and lawyers are equally competent judges; and, finally, because those rules afford an excellent illustration of the old saying that the common law is the embodiment of common sense.

No. 7.—AN INTRODUCTION TO POLITICAL ECONOMY.

By Sir R. C. BAKER, K.C.M.G., President, Legislative Council, South Australia.

(*Read Wednesday*, 12 *January*, 1898.)

No. 8.—THE FEDERATION OF BRITISH AUSTRALASIA: A SKETCH FROM A POLITICAL AND AN ECONOMIC POINT OF VIEW.

By J. T. WALKER, Fellow of the Institute of Bankers (London).

(*Read Wednesday*, 12 *January*, 1898.)

[*Abstract.*]

SUCH was the title of a paper by Mr. J. T. Walker, which, in his unavoidable absence, was read on his behalf by Mr. R. Teece, F.I.A., before the Economic Section of the Australasian Association for the Advancement of Science on the above date.

A distinction having been drawn between Australasia and British Australasia, it was taken for granted that sooner or later a federation of the British territories in Australasia will become an accomplished fact, and aspirations in that direction, therefore, surely deserve encouragement. The Dominion of Canada was instanced as exemplifying the greater influence exercised by federated colonies over that which belonged to the same colonies prior to federation, and it was predicted that a similar experience awaited British Australasia. Federation was politically considered from three points of view—the Australasian or Colonial, the British or Imperial, and the Foreign. Each was enlarged on: thus, from the Colonial, federation should abolish artificial borderlines as regards duties, extend commercial intercourse between the colonies, institute a uniform Customs tariff, amalgamate the defence forces, the Postal and Telegraphic Departments, introduce a uniform system of quarantine, and attract emigration from Europe, besides superseding provincialism by a growing sentiment of nationhood. From the Imperial point of view, Federation symbolised the unity of the empire, and lessened the danger of friction between the Home and the Colonial Governments, as official communications, other than through the Governor-General, would go through one channel, the High Commissioner, in place

of through several Agents-General. A mother state naturally looks to her colonies for an outlet for her surplus population, and expects that, so far from entailing financial loss to her, those who depart will, by emigrating, increase her trade and her national importance, at the same time giving more elbow room to those at home who might otherwise be overcrowded. Colonies will naturally be more self-reliant federated than unfederated, and therefore should be a source of greater strength to the Empire in times of difficulty or danger. From the Foreign point of view, federation would emphasise the fact of the wonderful adaptability of the British race to altered and altering environment, and would presage a confederation of English-speaking communities able and willing not merely to defend themselves in time of need, but to assist the parent State should she unfortunately be attacked. Such a Commonwealth as that of Australasia, judging by the precedent of the United States of America, would attract a large share of continental emigration, and ultimately increase, commercially and otherwise, the power of the British Empire possibly, at the expense of her European rivals. Federation might also impress upon European nations the wisdom and feasibility of exchanging territories, so as to minimise the danger of political complications through undue proximity. Historic precedents are not wanting, as witness Louisiana, Alaska, and Heligoland.

In considering the question from an economic point of view, attention was directed to the fact that there is a border line in which it is not easy to differentiate the political from the economic—the two are at times interlaced, as for instance in the question of intercolonial freetrade. Confining oneself to the economic aspect of federation, the examples of Germany and Canada prove that the abolition of border customs enormously increased internal trade, and the establishment of local manufactories. Federation should, in time, promote greater economy in cost of government. Amalgamation of various governmental departments, such as Customs, Postal, Telegraphic, &c., must mean the lessening of expense. The various Agents-General should merge into one High Commissioner; one Postmaster-General ought to suffice; and the reduction in number and in emoluments of provincial legislators all point in the same direction. It should only be a matter of time to have a unification of the railway gauges, the expense being borne by the Federal Government; and the conversion and consolidation of the public debts, when accomplished, should result in a greater saving in annual charge for interest than all the other savings combined. The establishment of a Federal High Court should provide an alternative final Appeal Court to that of the Privy Council, and should tend in many cases to greater simplicity, quickness, and economy in legal procedure,—itself a valuable economic gain. It is believed it

will greatly advantage the State to have a Federal Government Legal Tender Note Issue on a convertible gold basis, available as currency throughout the length and breadth of the Federation, and under the management and control of non-political Commissioners.

In general remarks on the whole subject, allusion is made to the first tariff likely to be established under the Federal Government. It is believed a compromise between freetraders and protectionists will take the form of a revenue tariff with a protectionist incidence of a moderate complexion—possibly supplemented, in the case of some infant industries, by what is designated "graduated vanishing bonuses." Attention is drawn to the fact that freetraders indulge the hope that, as the advantages of intercolonial freetrade are experienced, so will the desire grow for the extension of the principle. It is believed moderate and "discriminating" protectionists will see the necessity of coalescing in time with the freetraders, although, just at present, the colonies favouring protectionist tariffs are apparently in the majority. The regulation of coloured labour will be a difficult problem to solve; but it is hoped 26° south latitude will be accepted as a "colour line," north of which, for tropical agriculture, a limited continuance of well-regulated island and other labour may be permitted, subject to the labourers being returned to their homes at the expense of their employers at the termination of engagements. The question of a Federal Civil Service is referred to, and a means is suggested by which it will be kept free from political patronage, and promotion shall depend on merit alone. In the Appendix are several tables which supplement the information in the paper, and in them will be found interesting reference to the United States, to Canada, to Switzerland, and to Germany—all bearing more or less on the question of federation, with statistics, which are self-explanatory. There is a curious and interesting extract from the defunct *Colonial Magazine*, of March, 1840, which conclusively shows that at that time—fifty-seven years ago—there were writers who held what are even now the prevalent views respecting the great advantage to Great Britain of having colonies for her surplus population, so that her emigrants might not go to strengthen her rivals, but rather to strengthen herself:—"The migration of individuals from one part of a kingdom or empire, to another part of the same kingdom or empire, is decidedly beneficial; existing deficiencies are supplied, the condition of the migrators improved (or else they would not have migrated), and knowledge is extended and increased by promoting facility of intercourse between distant communities, for an incalculable benefit is derived from the interchange of mind, as well as from the transfer of merchandise. It is those generally who are strong of heart, and in full bodily health, who migrate;

and if the migrators do not quit the island, kingdom, or empire, the general weal is not diminished, as the improvement of the condition of the migrators benefits the whole community; but if they quit their native country to reside in a foreign land, the strength of those who remain is diminished, while the young and the aged, the feeble and the indigent, are thrown for support on the reduced resources and increasing care of those who have not migrated. Moreover, it can never be the true policy of a nation to strengthen a neighbouring or rival state by the addition of skilful artisans, while the nation is becoming daily weaker from the additions thus made to the power of its neighbour."

Towards its conclusion the paper refers, by analogy, to geology and astronomy, and does not see why the horizon of political economists should not also be extended backwards or forwards a few hundred years if need be, to see the working of the political economic principles—and, remembering that principles are eternal, contrast what has happened with what may be expected to come to pass. Compare the United States of 1776 with 1897, whose population has increased from three millions to seventy-two millions in 121 years—and contrast Great Britain, A.D. 1066, with the British Empire, A.D. 1897. What may therefore not be expected of a federation of British Australasia as years go by?

No. 9.—STATE AID TO AGRICULTURE AND INDUSTRY.

By H. L. E. Rüthning.

(*Read Wednesday*, 12 *January*, 1898.)

No. 10.—NOTES ON A STATISTICAL COMPARISON OF THE AUSTRALIAN RAILWAYS WITH THE CANADIAN RAILWAYS.

By W. Walker.

(*Read Wednesday*, 12 *January*, 1898.)

AGRICULTURE PAPERS.

No. 1.—THE MAKING AND IMPROVEMENT OF WHEATS FOR AUSTRALIAN CONDITIONS.

By W. Farrer, B.A.

(*Read Monday*, 10 *January*, 1898,)

Published in full, *Agric. Gaz.* of N.S.W., vol. IX., Parts 2 and 3.

[*Abstract.*]

The author gives an account of the origin of the work and the principles on which it has been conducted. The work of carrying out systematic experiments in the selection and cross-breeding of wheats was commenced by the author in 1886. The qualities whose improvement was specially aimed at at first were—(1) increased rust-resistance, and (2) increased gluten content of grain.

The author then discusses the relative merits of the two methods of improving the wheat plant—First, by selection alone; secondly, by cross-breeding, combined with selection; summing up in favour of the second method.

He next describes the details of the work, including his method of selecting, crossing, harvesting, making, &c. of the wheats; and points out the advantage, in the case of the wheat plant, of castrating before pollinating.

Detailed information is next given regarding the history of some wheats he obtained, whose behaviour was of special interest.

An experiment is next described showing that when the authors are from any cause unable to effect self-pollination, fertilization takes place from outside.

The author has found (1) that the male-element occasionally affects the appearance of the seeds which result from artificial pollination, (2) excessive drought has the effect of diminishing the potency of the pollen on its own stigma.

The history and behaviour of a number of hybrids is next dealt with.

The author then proceeds to discuss (1) the origin of our bread-wheat plants, and suggests a method by which the original ancestor or ancestors may be ultimately discovered. He thinks an indication as to the possible ancestry of our cultivated bread-wheats is afforded by certain "grass clump" plants, which he has observed to appear occasionally when certain widely-distinct types of bread-wheats are crossed, and which appear to be of the nature of reversions to the original type; (2) the duration in the wheat-plant of the increased vigour which results from a cross; (3) the process of acclimatisation, the conditions which render it possible, and the manner in which the process may be expedited in the case of plants propagated from seed.

The author proceeds to the discussion of the qualities of a wheat which are specially demanded by our climatic conditions. These are :—

1. Ability to thrive in dry soils.
2. Habit of stooling sparingly.
3. Earliness in ripening.

Dealing next with the question of rust, the author points out the present position of the rust problem, and expresses the opinion that the practical solution of the problem is easy of accomplishment, and has possibly even been already accomplished as far as the interior of Australia is concerned.

He next points out the qualities in the grain which determine its excellence for milling and bread-making, and particularly its food value.

Finally, the author points out the improvements in the grain which will be necessitated by the impending deficiency of bread-stuffs owing to the increase of population and the impossibility of materially increasing the wheat-growing area.

At the close of the above paper, Mr. Farrer read a short communication prepared by Professor Eriksson, Stockholm, Sweden, containing the main results of an investigation into rusts which affect cereal crops in Sweden.

No. 2.—BACTERIOLOGY, IN RELATION TO AUSTRALIAN DAIRYING.

By M. A. O'Callaghan, Dairy Expert to the Department of Agriculture, N.S. Wales.

(*Read Monday*, 10 *January*, 1897.)

Published in *Agricultural Gazette* of N.S.W., Vol. IX, Part 2.

No. 3.—THE PROPAGATION OF FRUIT TREES.

By A. H. Benson, M.R.A.C., Agricultural Department, Queensland.

(*Read Monday*, 10 *January*, 1898.)

No. 4.—GRAMINEÆ OF WESTERN AUSTRALIA.

By F. Turner, F.L.S., F.R.H.S.

(*Read Monday*, 10 *January*, 1898.)

No. 5.—SALSOLACEÆ OF WESTERN AUSTRALIA

By F. Turner, F.L.S., F.R.H.S.

(*Read Monday*, 10 *January*, 1898.)

No. 6.—THE SUPPOSED POISONOUS PLANTS OF WESTERN AUSTRALIA.

By Fred. Turner, F.L.S., F.R.H.S., &c.

(*Read Monday*, 10 *January*, 1898.)

In no part of Australia has the subject of supposed poisonous plants received more attention from explorers, botanists, plant-collectors, pastoralists, and farmers, than in the western portion of the continent. Almost ever since domestic animals were introduced into Western Australia certain plants have been suspected of having poisonous properties, and it appears that some of these are suspected not without sufficient reason. As far back as the year 1840, Mr. James Drummond, who was an excellent botanist, and an indefatigable collector of West Australian plants, wrote to Sir William Hooker, Director of the Royal Botanic Gardens, Kew, London, about a certain species of *Gastrolobium* which was regarded as poisonous to stock. Subsequent to that date Drummond wrote many interesting papers on West Australian plants, including those that were suspected of having poisonous properties, which were published in Hooker's "London Journal of Botany." In the year 1841, Dr. Joseph Harris, Colonial Surgeon of Western Australia, Drummond, and several other gentlemen experimented with certain leguminous plants belonging, or closely allied, to the genus *Dillwynia* by feeding them to stock, and the animals are reported to have died shortly afterwards. This was considered conclusive proof that the plants contained toxic properties; but at that time no analyses appear to have been made to determine the poisonous principle, if any, in these plants. During recent years many references, notably by the late Mr. G. Bentham in the *Flora Australiensis*, and by the late Baron Von Mueller in some of his publications, have been made with regard to the supposed poisonous properties of certain plants, but nearly the whole subject is ruled by empiricism. A few systematic attempts have been made to analyse certain suspected poisonous plants and to place the results on record; but as I pointed out many years ago, there are few subjects in the domain of science where more original and valuable work could be accomplished. In order to obtain results which would be of the greatest possible benefit to stock-owners, the plants should be thoroughly investigated, both from a chemical and physiological point of view. Some years ago the New South Wales Government, at my suggestion, began to analyse the supposed poisonous plants of the parent Colony. [See Fred. Turner's

and F. B. Guthrie's description and analysis of the "Darling Pea," "Indigo," "Cranky Pea," &c. (*Swainsona galegifolia*, R. Br.), *Agricultural Gazette*, IV, 84 (1893)]. This paper also contains notes of the experiences of a number of New South Wales and Queensland graziers in regard to the plant. Quite recently, the West Australian Government has been investigating some supposed poisonous plants. [See the fourth Annual Report of the Bureau of Agriculture of Western Australia (1897)].

In many parts of Western Australia the pastures are composed of a great variety of plants which, in many respects, are dissimilar to those found in other countries. Amongst such a diversity of herbage it can easily be supposed that when any horses, cattle, or sheep have died in a somewhat mysterious way, different kinds of this vegetation have at one time or another been suspected of having poisonous properties. During very dry seasons, when the more tender grasses and herbage are dried up, the green leaves of many trees and shrubs offer a tempting bait to pasture animals, and are greedily eaten by stock, though there is still much to be cleared up with respect to the actual value of certain of them. Even in the same district, some persons will assert that a particular species of plant is poisonous, while others, whose testimony is equally reliable, will assert that it makes capital feed. There are, perhaps, no more conflicting statements made than with regard to certain species of the genus *Eremophila* and the allied one *Myoporum*. Whilst I must admit that very little is known of the physiological properties of the order *Myoporineæ*, still I cannot close my eyes to the fact that both sheep and cattle kept in country where these plants are plentiful eat them with avidity, and seem to thrive on them without any ill effects. Some persons assert that these *Myoporinous* plants develop their poisonous properties when in fruit; but whoever has studied the habits of the birds of the interior will assure you that certain of these greatly depend upon the fruits of these plants for their sustenance, which, in fact, are in some seasons, their principal food supply. Moreover, the aborigines, before they tasted the sweets of civilisation, used to eat the fruits of several *Myoporinous* plants.

There is no doubt that when cattle and sheep are taken from one district to another, where the natural herbage is somewhat dissimilar, it must have, for a time at least, some effect upon their systems, especially when they are taken from rolling downs of grass to country where shrubs and herbs predominate; and this brings to mind a question which, I think, has not received that attention from stock-owners that its importance justifies. It is the mechanical action which hard-foliaged shrubs have upon the larynx of both cattle and sheep that are not used to eating them. This irritation of the larynx not only brings on laryngitis, but

sometimes tends to bring on inflammation of the intestines. Further, when hungry sheep and cattle have partaken too freely of certain leguminous plants, especially when in flower or seed, they have died. But this is caused during the process of digestion, when great quantities of gases are made, which cause an abnormal distention of the stomach, thus preventing the lungs working freely, and, of course, strangling the animals; this is technically known as tympanitis, or hoven. On this account many leguminous plants are sometimes classed as poisonous, which are not really so. As has already been remarked, there is much diversity of opinion amongst pastoralists and farmers with regard to certain shrubs, and, although I append a list, with common descriptions, of those plants which I have received from the West Australian Government and from a large number of stock owners for identification as being suspected of poisoning or causing injury to cattle, horses, and sheep, there must be future careful investigation on the lines already indicated before anything very definite can be stated.

RANUNCULACEÆ.

Ranunculus lappaceus, Sm.—"Buttercup."

This perennial plant is common in certain shady and moist situations in the coastal districts, and on alluvial lands bordering some rivers and creeks. The leaves, which are chiefly radical and arranged on long stalks, are usually deeply divided into three or five deep lobes or segments. Flowers large, of a rich yellow colour.

PAPAVERACEÆ.

* *Argemone mexicana*, Linn.—"Devil's Fig," "Prickly Poppy," &c.

This spiny-leaved, thistle-like Mexican plant has established itself in a few places, but principally near settlement. For further information as to its properties, &c., see my figure and description of the plant in the *Agricultural Gazette*, New South Wales, Vol. II, page 175, 1891; also in the publications of the West Australian Agricultural Department, 1897.

ZYGOPHYLLEÆ.

Zygophyllum idocarpum, F.v.M.—"Bean Caper."

Although this small, many-branched annual has been suspected of poisoning or causing injury to stock, some allied species are well known vermifuges. Several have been figured and described by me in the *Town and Country Journal*.

LEGUMINOSÆ.

Brachysema undulatum, Ker.—"Poison Bush."

An erect shrub, with weak or pendulous branches, which are silky-pubescent when young. The leaves are very variable, and

range from broadly ovate or almost orbicular to narrow oblong or almost linear. Flowers yellowish-green, or almost black, rarely red, axillary. Pod ovoid and very hairy.

Oxylobium retusum, R. Br.—"Bloom Poison Plant."

A many-branched, rigid shrub, the young branches of which are angular and sometimes hairy. The leaves are mostly opposite, stalked, ovate or oblong, obtuse, truncate or notched at the end, usually 1 inch to 2 inches long, leathery, net-veined above and silky hairy underneath. Flowers reddish-yellow in dense, almost stalkless, terminal clusters, or rarely also in the upper leaf axils. Pod ovoid, about one-third of an inch long, and very hairy.

Oxylobium parviflorum, Benth.—"Box Poison."

A tall, spreading shrub, with alternate, opposite, or in threes, narrow-oblong, slightly cuneate or linear leaves. The flowers are small, orange-yellow and purple, in slender racemes, terminal, or in the upper axils, often 2 to 3 inches long. Pod from a quarter to half an inch long. This is said to be one of the worst poison plants in the Colony.

Isotropis juncea, Turcz.—"Rush Poison."

This plant produces numerous, slender, wiry, slightly angular or compressed stems from a perennial stock. The leaves are very few, chiefly in the lower part of the stem. Flowers yellow with purple streaks, arranged in loose, terminal racemes. Pods long, containing about thirty seeds.

Gompholobium tomentosum, Labill.—"Poison Bush."

An erect shrub of about 3 feet high; the young branches villous. Leaves usually consisting of five to seven, but varying from three to eleven, narrow-linear leaflets. Flowers yellow, few, and terminal. Pod scarcely half-an-inch long, containing numerous seeds.

Gastrolobium obovatum, Benth.—"Poison Bush."

The branches of this shrub are rather slender and tomentose. The leaves are mostly obovate, under 1 inch long, coriaceous and reticulate. Flowers small, in axillary, rather loose clusters.

Gastrolobium trilobum, Benth.—"Poison Bush."

This is a many-branched, slender-growing shrub. The leaves are usually three lobed, about 1 inch long, and tapering into a pungent point. Flowers few, in loose, axillary racemes, not usually exceeding the leaves.

Gastrolobium ovalifolium, Henfr.—"Bloom Poison Bush."

This is a low-growing shrub with mostly opposite, ovate, or broadly oblong leaves rarely more than 1 inch long. Flowers nearly sessile on slender racemes 1 inch to 3 inches long. Pod about a quarter of an inch long.

Gastrolobium spinosum, Benth.—"Spiny-leaved Poison Bush."

A shrub attaining sometimes a height of 4 or more feet, with opposite, broadly ovate leaves, which end in a pungent point, and are bordered by sharp-pointed teeth. The flowers are rather large and arranged in loose racemes about 2 inches long. Pod curved, scarcely half an inch long.

Gastrolobium oxylobioides, Benth.—"Poison Bush."

An erect shrub, rarely growing more than 2 feet high, with broad or narrow leaves either opposite or in threes, and scarcely 2 inches long. The flowers are arranged in short, terminal racemes. Pod about a quarter of an inch long.

Gastrolobium calycinum, Benth.—"York-Road Poison Bush."

A glabrous, erect-growing shrub, with oblong or lanceolate leaves, opposite or in threes, 1 inch to 2 inches long. The few large flowers are arranged in terminal or axillary racemes.

Gastrolobium callistachys, Meissn.—"Rock Poison Bush."

An erect-growing shrub attaining sometimes a height of 3 or more feet, with slender, twiggy, silky-pubescent branches. The leaves are alternate, or irregularly verticillate, very narrow, and from 1 inch to 2 inches long. The flowers are rather large, and arranged in terminal racemes about 4 inches long. Pod about one-third of an inch long.

Gastrolobium parvifolium, Benth.—"Berry Poison Plant."

A rigid, spreading, heath-like plant, with crowded, narrow oblong leaves under half an inch long. The small flowers are borne in rather dense, terminal racemes, rarely exceeding 1 inch long when in bloom, often 2 inches when in fruit. The glabrous pod is nearly globular.

Gastrolobium bilobum, R. Br.—"Heart-leaf Poison Bush."

A tall-growing shrub, with angular branches, which are usually silky-pubescent. The leaves are arranged in whorls of three or four together, variable in shape, but generally two-lobed, and about 1½ inch long. The numerous flowers are arranged in very short, terminal racemes, rarely exceeding the leaves. Pod ovoid or oblong, about a quarter of an inch long.

The prevailing colour of the flowers in the above species of *Gastrolobium* is yellow, but the keel (lower petals) and base of the standard (upper petal) are often purplish-red.

Templetonia retusa, R. Br.—"Poison Bush."

A tall, glabrous, glaucous shrub, with angular, furrowed branches. Leaves variable, thick, and leathery, and about 1 inch long. The flowers, arranged in the leaf axils, are usually red, but sometimes white. The oblique pod is about 2 inches long, and about half an inch wide.

Goodia lotifolia, Salisb.—"Yellow Pea," or "Yellow Indigo."

This a rather tall-growing straggling shrub, with pinnately three-foliate leaves, and many-flowered racemes of yellow flowers. The pods are nearly an inch long, and about one-quarter of an inch broad.

Crotalaria cunninghamii, R. Br.—"Poison Plant."

A shrub, growing about 3 feet high, and covered all over with a dense, soft tomentum. The leaves are usually broadly ovate, and from 1½ to 3 inches long. The very large flowers are of a yellowish-green colour, more or less streaked with dark lines. They are arranged in terminal racemes. The tomentose, leathery pods are about 1½ inch long.

Lotus australis, Andr.—"Poison Trefoil."

A perennial plant of rather variable habit. Sometimes it forms a dense little bush of about 2 feet high, while in other situations it has weak, straggling growths. The leaves are composed of five leaflets, three at end of the stalk and two close to the stem. Flowers usually pink and fragrant, but varying much in colour from white to purplish, with a leaf close under each umbel of flowers. Pod cylindrical, about 1½ inch long.

Indigofera australis, Willd.—"Wild Indigo."

This is an erect branching shrub of from 2 to 4 or more feet high, with leaves composed of numerous, small leaflets—usually nine to seventeen—and pink or purple flowers arranged on axillary racemes. The pods are about 1½ inch long, terete, and nearly straight.

DROSERACEÆ.

Drosera gigantea, Lindl.—"Sun Dew."

This plant has tall, branching, leafy stems, with variable leaves, the lower ones reduced to lanceolate scales, but the upper ones are generally broadly crescent-shaped. The small white flowers are borne on large, loose, branched, terminal panicles.

UMBELLIFERÆ.

Trachymene australis, Benth.—"Wild Parsnip."

A rather coarse plant, with leaves either radical or at the base of the stem, and hispid, with long hairs. Flower stalks long and distant, each bearing an umbel of numerous, small flowers. Stalks on the main stem, sometimes several together, so as to form a large, irregular, compound umbel. The whole plant is acrid.

COMPOSITÆ.

Myriogyne minuta, Less.—"Snuff Weed."

A prostrate, branching plant, with slender stems, more or less clothed with short, woolly hairs. The oblong, toothed leaves rarely exceed half an inch in length, and are often much shorter. Flower heads very small, solitary, and mostly leaf-opposed. The whole plant has a slight pungent scent when bruised.

GOODENOVIEÆ.

Velleia macrophylla, Benth.—"Yellow Poison Plant."

A glabrous, erect, leafy, branching plant, attaining sometimes a height of 4 feet. Stem leaves from 2 to 6 inches long, toothed, and narrowed into a long stalk. Flowers rather large, borne in axillary panicles. There are one or two forms of this fine plant.

CAMPANULACEÆ.

Lobelia heterophylla, Labill.—"Blue Poison Plant."

An erect growing, annual plant, with very variable leaves, the lower ones sometimes pinnatifid with a few, narrow, linear lobes, or obovate and deeply cut; the upper ones small, linear, and entire. Some forms, however, have oblong-linear, obtuse, almost entire leaves. Flowers rather large, in a loose, one-sided raceme. The oblique capsule is full of small, winged seeds. Some forms of this species having entire leaves resemble *Isotoma brownii*, G. Don., Syn. *Lobelia hypocrateriformis*, R. Br.; but besides other minor differences the anthers of *L. heterophylla* are all tipped with a dense tuft of short bristles, while the anthers of *I. brownii* are always glabrous.

Isotoma brownii, G. Don.—"Poison Plant."

A glabrous, erect, simple or slightly-branched annual, rarely exceeding 1 foot in height; with narrow leaves, usually from half to one inch long. Flowers often numerous, in a loose, one-ided raceme. The oblique seed-vessel is from a quarter to half an inch long.

SOLANEÆ.

Solanum nigrum, Linn.—"Nightshade."

An erect annual or biennial plant, with spreading branches and ovate leaves, often with coarse irregular annular teeth, 1 inch to 3 inches long. Flowers small and white, arranged in little cymes. These are succeeded by small, globular berries, usually nearly black, but sometimes greenish-yellow or dingy red. The forms that bear the two last coloured fruits are considered the most dangerous. The black-coloured berries are freely eaten by children.

* *Datura stramonium*, Linn.—"Thorn Apple," "Devil's Trumpet," "Stink Weed."

This poisonous weed has established itself in a few places, but principally near settlement. For further information as to its properties, &c., see my figure and description of the plant in the *Agricultural Gazette*, New South Wales, Vol. II, page 311, 1891. Also in the publications of the West Australian Agricultural Department, 1897.

Nicotiana suaveolens, Lehm.—"Native Tobacco."

An erect-growing, annual or biennial plant, attaining sometimes a height of 4 feet or more. The lower leaves are ovate, and often more than 1 foot long; the upper ones smaller and narrower. Flowers white and fragrant, but variable as regards size and form. Seeds numerous.

SCROPHULARINEÆ.

Anthocercis viscosa, R.Br.—"Poison Bush."

An erect-growing shrub, attaining sometimes a height of 20 feet, and more or less viscid. The leaves are broadly ovate, and from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long. Flowers beautifully white, and sometimes nearly 2 inches in diameter. Capsule about three-quarters of an inch long and pointed. For further information see my figure and description of the plant in the *Town and Country Journal*, 1895.

Anthocercis littorea, Labill.—"Poison Bush."

An erect-growing shrub of from 2 to 8 feet, the whole plant slightly viscid. The rather thick leaves vary from oblong wedge-shaped to inversely egg-shaped, and are generally $\frac{3}{4}$ to $1\frac{1}{2}$ inch long. The numerous small yellow flowers are produced on slender, short stalks, forming at the ends of the branches leafy racemes or leafless panicles of 1 foot long or more; capsule narrow, often half an inch long and pointed.

* Those plants that are marked with an asterisk are introduced.

Morgania floribunda, Benth.—"Poison Herb."

A perennial plant, usually attaining a height of 1½ foot, glabrous or nearly so, and more or less glaucous. Leaves linear or narrow lanceolate, and about 1 inch long. Flowers about half an inch long, bluish, and often clustered with small leaves in the axils of the branchlets. Capsule shortly pointed, and containing numerous small seeds.

Gratiola peruviana, Linn.—"Poison Herb."

The succulent stems of this plant grow from 6 inches to 1 foot high, and are more or less viscid—pubescent. The leaves are opposite, stem clasping, and from ovate to lanceolate, usually three-nerved when broad, and ½ to 1 inch long. Flowers sessile or nearly so in the upper axils, and about half an inch long. Capsule avoid-globular, containing small seeds.

LABIATÆ.

**Stachys arvensis*, Linn.—"Hedge Nettle," "Stagger Weed," &c.

This common weed of cultivation has established itself in a few places, but principally in cultivated fields. For further information as to its properties, &c., see my figure and description of the plant in the *Agricultural Gazette*, N.S.W., Vol. I, page 307, 1890. Also in the publications of the West Australian Agricultural Department, 1897.

PHYTOLACCACEÆ.

Gyrostemon ramulosus, Desf.—"Camel Poison."

An erect, many-branched shrub, attaining sometimes a height of 8 or more feet, and often of somewhat fleshy habit. Leaves linear-terete, thick or slender, 1 inch to 3 inches long. The male and female flowers, which are borne on separate plants, are arranged on short, axillary, reflexed stalks. Fruit more or less pear-shaped, and composed of a number of carpels (fruitlets).

EUPHORBIACEÆ.

Euphorbia drummondii, Boiss.—"Caustic Plant."

A prostrate or diffuse, many-branched plant, the stems and leaves of which abound in a milky juice. The leaves are opposite, nearly round or oblong, and about a quarter of an inch long. Some plants are of a light grey colour, but others have reddish stems and leaves. The flowers and fruits are very small, and arranged in the upper leaf axils.

* Those plants that are marked with an asterisk are introduced.

Euphorbia eremophila, A. Cunn.—" Poison Plant."

An erect, rigid-growing plant, rarely attaining more than 1 foot in height, and often only 6 inches. The whole plant abounds in a milky juice. The linear or oblong leaves are about 1 inch long. The flowers and fruits, which are very small, are arranged singly in the leaf axils.

Beyeria viscosa, Miq.—" Poison Bush."

A tall shrub or small tree, the flowering and fruiting branches usually viscid. The leaves are exceedingly variable in length and breadth, and in the whiteness of the under surface. Flowers arranged on axillary recurved stalks, about half an inch long, the females singly and the males often two or three together. Fruit ovoid, about one-third of an inch long, hard and glutinous.

CYCADEÆ.

Macrozamia spp.—" Burrawang," " Wild Pine Apple," " Zamia Palm."

See my description of *Macrozamia miqueli*, F.v.M., and its relation to the disease known as rickets in cattle (*Agricultural Gazette*, New South Wales, Vol. IV, page 158, 1893). See also my figure and description of the plant (*Town and Country Journal*, 1892).

LILIACEÆ.

Bulbine semibarbata, Haw.—" Native Leek."

A fibrous rooted plant with usually narrow-linear, radical leaves, from a few inches to about a foot long. The small, yellow flowers are arranged on stalks, about a foot long. The small fruits usually contain three or four black, angular seeds when ripe. This plant is usually found on wet, sandy land.

Stypandra glauca, R.Br.—" Blind Poison Herb."

A perennial plant, with leafy stems, attaining sometimes a height of 3 feet and branched at the base. Generally, however, the plant is much lower. The leaves are linear or lanceolate, usually 3 or 4 inches long, but sometimes twice that length. The beautiful, rather large, blue flowers are borne in terminal cymes. The fruit is about a quarter of an inch long, containing several flat, smooth seeds.

No. 7.—APPLIED ENTOMOLOGY IN WESTERN AUSTRALIA.

By Claude Fuller, Assistant Entomologist to the Government of Cape Colony (Late of the Bureau of Agriculture, Perth).

(*Read Tuesday*, 11 *January*, 1898.)

The author defines briefly the ends and aims of economic entomology, and refers to the rapid strides which this science has made of recent years in Australia, alluding more particularly to legislation for the purpose of eradicating insect-pests. In this work West Australia is the most advanced of the colonies, and the author traces the inception of the Acts relating to the exclusion of imported pests and the suppression of those already in existence. The Act dealing with imported pests arose from the fact that the codlin moth did not occur in the orchards of West Australia, and the effective administration of the Act has prevented its introduction up to the present. The author regards the indirect benefits as being very important, since consignors of fruit are careful only to send clean fruit, knowing that it will be condemned if the slightest trace of disease appears.

As showing the effective working of the Act dealing with diseased orchards, the author points to the eradication of the San José scale. This Act is also indirectly beneficial, as the orchardists and farmers are induced to learn something about these pests, and in most cases to purchase a spraying outfit.

The author then describes a few of the commoner pests in West Australia, and the orchard pests. The most abundant are the scale insects and aphides, the number of scale insects which are destructive being very small in W.A., although other scales are abundant. A large number of destructive species have been stopped at the ports, and their introduction has to be guarded against.

The absence of the codlin moth is a fact on which the colony prides itself, but the fruit-fly is very prevalent. The author points out that the W.A. fruit-fly differs from the two species found in N.S.W., and there is some difficulty in locating its original home. Mr. Fuller inclines to the belief that it has come to W A. from the Mediterranean. He then gives a few observations concerning this pest and its distribution in W.A., and describes some experiments he has made in order to combat it. These included spraying with a mixture containing kerosene soap and tar-oil, and placing commercial sticky fly-papers on and about

the infested trees. Neither treatment yielded satisfactory results.

The action of gas-lime was also tried by placing the maggots in mixtures of gas-lime and soil in different proportions. The gas-lime was apparently without effect upon them.

In an orchard where there was a flow of artesian water it was found possible to drown out the maggots by making a circular dam round the trees and keeping them flooded for a few days.

Another plan was to pick the fruit unripe, and allow it to ripen under shelter.

Of vineyard pests the most destructive in W.A. are the cut-worms, which are in nearly every vineyard, the most effective remedy being a poisonous bait of bran and Paris Green. The common vine-moth does not occur; neither does Phylloxera Vastatrix. Nearly all the pests common to vegetable gardens in the eastern colonies have found their way into W.A.

No. 8.—ECONOMIC ENTOMOLOGY.

By W. W. Froggatt, Entomologist to the Department of Agriculture, N.S.W.

(*Read Tuesday*, 11 *January*, 1898.)

Published in *Agricultural Gazette* of N.S.W., vol. ix, Part 3.

No. 9.—ON THE PINE TREES OF NEW SOUTH WALES.

By R. T. Baker, F.L.S., Curator, Technological Museum, Sydney.

(*Read Tuesday*, 11 *January*, 1898.)

No. 10.—MILK ANALYSIS IN ITS RELATION TO THE BUTTER AND CHEESE INDUSTRIES.

By H. W. Potts, F.C.S.

(*Read Tuesday*, 11 *January*, 1898.)

No. 11.—WINE CULTURE IN N. S. WALES.

By F. B. Kyngdon, M.R.A.C.

(*Read Tuesday*, 11 *January*, 1898.)

HISTORICAL SKETCH.

Wines of excellent quality have been produced in N. S. Wales from an early date. The first grape vine in Australia is said to have been planted at Castle Hill in November, 1791, by Colonel de la Campe, a French emigrè. Mr. George Suttor planted his first grape vine near Parramatta in 1801. Mr. John Macarthur, doubtless, had noticed how well grape vines grew, for as soon as Europe was opened to travellers after the peace of 1815, accompanied by his two sons, James and William, he visited the leading vineyards of France and Spain, chiefly on foot, and collected cuttings of about thirty of the most renowned varieties of vines and entrusted them with a London nurseryman for forwarding to Sydney. On the return voyage, the ship stopped at Madeira and the vineyard proprietors promised to forward in due time cuttings of their seven choice varieties. This spirited effort to place wine culture on a sure foundation by introducing the best varieties in the world was doomed to failure. When the cuttings arrived, they were planted at Camden Park, and in course of time bore grapes that were strangely inferior to those they were supposed to represent, and their wines were equally so. Not till many years afterwards were suspicions rendered certainties. In 1825 the Australian Agricultural Company sent out from Chiswick cuttings of the true Madeira and Muscat varieties, which, when they fruited, proved the Macarthur collection to have been tampered with. The London nurseryman had evidently substituted a common grape, and the Madeira vineyard proprietors had sent worthless sorts. Not only did Mr. Macarthur recognise the need of the best grape vines, but the introduction of skilled vinedressers to tend them. Application was made to the British Government to introduce foreigners under the existing bounty system, but it was needlessly refused, and it was not until 1844 that such men arrived in the colony. The early cultivators of the vine learnt much from repeated failures, and persevered under every disadvantage. One and all were pursuaded of the fitness of soil and climate for vine culture, and Mr. William Macarthur [afterwards Sir William] was particularly enamoured with the suitability of the eastern counties of N.S. Wales. A true Verdeilho grape was imported by the A.A. Co. in 1825, and the Macarthurs obtained some cuttings, as well as of two sorts of Muscat, and from them small quantities of wine were made, and these proved that the earlier failures were due to inferior varieties and not to the soil. There are few records extant of Australian

viticulture during the 'twenties. Sir Daniel Cooper stated before the Society of Arts, London [1873], that he recollected grapes being sold in Sydney in 1826. Prior to 1830, Mr. Sadleir produced good wine at the Orphan School vineyard on the Nepean. Mr. Gregory Blaxland cultivated in his original vineyard at Brush Farm the small black cluster Burgundy Pineau and Miller's Burgundy. This was in 1817. He visited London in 1822, taking with him some wine of his own making, for which he was awarded the silver medal of the Society of Arts. Again he visited London in 1828, submitting further samples of his own wine, for which he received the Ceres gold medal of the Society of Arts. Contemporary with the Macarthurs as a pioneer of the wine industry was Mr. James Busby. In 1822 he visited the wine districts of Europe. Again in 1831 he left Sydney, on a more extended tour. Prior to embarking, he distributed 20,000 wine cuttings amongst upwards of fifty settlers, and thereby widely extended wine culture. He took with him 10 gallons of Orphan School wine, vintage 1829, which he bottled in London and distributed among persons interested in the colony. It was at the instance of the Macarthurs that this trip was taken, under instructions to ascertain to what peculiarities of climate, soil, or culture the most celebrated wine provinces of Europe are indebted for the excellence of their respective products, and to make a collection of the varieties of vines cultivated in each. The narrative of his travels was published in Sydney in 1833 and a third edition in London in 1840, under the title of a "Journal of a Tour through some of the Vineyards of Spain and France." It forms interesting reading to-day, and throws an instructive light upon the European wine methods of sixty-six years ago. Mr. Busby secured cuttings from all the celebrated vineyards, forming his own collection. When at Montpelier he was fortunate in meeting Professor De Lisle, chief of the famous botanic gardens of that town, and Mr. Busby was allowed to himself take cuttings of 437 named varieties of grape wines, and what were wanting to make the collection complete were made up from the Royal Nursery of the Luxemburg. He moreover obtained permission from Lord Goderich, Secretary for the Colonies, that this extensive collection should be planted on vacant ground adjoining the Sydney Botanic Gardens. It arrived by the "Lady Harewood" on 12th August, 1832, and the vines were duly planted. Unfortunately, Mr. Busby had left for New Zealand, and without his supervision during the succeeding years the requisite care was not continually exercised, and in course of time all was confusion. Practically speaking, Mr. Busby had collected all the best varieties from the vineyards he visited, and the destruction of the Montpelier collection was no loss since the majority of the varieties were more curiosities than commercial

successes. The Macarthurs selected altogether forty of the choicest varieties for culture at Camden Park, and of these twenty were finally retained as good for wine-making. The expansion of wine culture dates from 1831, when Mr. James Busby distributed cuttings and so interested many settlers in the vine. The vineyard planted on Mr. Busby's Kirkton Estate is now the property of Mr. James Kelman. In 1832 Mr. James King established a vineyard at Irrawang, where the Williams joins the Hunter River. In 1837 Mons. D. J. Joubert established a vineyard, having brought from France a valuable collection of the best sort of the vines of Medoc, celebrated for clarets. In 1840 Mr. William Macarthur imported vine cuttings from the famous vineyards of the Rhine, and planted them at Camden Park. In 1844 some German vine-dressers came to the Colony, *via* New Zealand, and added a much-needed element of technical skill. In 1843 the late Dr. H. J. Lindeman planted a vineyard on the Cawarra Estate, Paterson River. In 1846 the late Mr. John Wyndham established the Dalwood vineyard on the Upper Hunter. During the same year Mr. William Wyndham planted vines at Bukkulla, on the M'Intyre River, near Inverell of to-day. In 1849 Messrs. G. T and J. B. Carmichael planted a vineyard at Porphory, near Seaham, on the Williams River. During the 'forties vine culture extended in the south-west of the Colony. The late Hon. E. D. Ogilvie planted the Merton Vineyard, on the Murray, in 1840. The late Mr. John Smith, of Kyandra, obtained vine cuttings, and having proved the suitability of his soil, sent to Germany in 1844 for vines and vine-dressers, and the journey of the latter overland from Sydney was no small undertaking. On expiry of their engagement with Mr. Smith, Messrs. Schuback, Fraunfelder, and Ran rented 10 acres from Messrs. Crisp, on the Murray, near Albury, on an improving lease, and the breaking out of the gold boom of the 'fifties gave them an exceptional profit for their wines, enabling them to purchase land at Albury and plant vineyards, and their success led to many other Germans coming out. The late Mr. J. M. Sangar planted a vineyard at Corowa, on the Murray, 40 miles from Albury, which was eventually purchased by Messrs. H. J. Lindeman & Co., who also acquired the adjoining vineyard founded by the late Mrs. Bladen Neill. So suitable was the soil and climate of the Murray deemed for wine culture that a large vineyard was established near Albury in 1861 by the Murray Vineyard Company, and in time was purchased by the late Mr. J. T. Fallon, and is now carried on by his brother. Mention must be made of Ettamogah, near Albury, where the ex-Surveyor-General, Mr. P. F. Adams, planted a vineyard that has attained the highest reputation. In 1875, when Mr. Adams ceased to reside at Albury, it passed into the hands of Messrs. Harbottle, Alsop, & Co., and under the management of Captain Lankester.

In this rapid sketch of the extension of wine culture it has not been possible to introduce the names of more than a few of those who have built up the wine industry of to-day, the object having been to trace the establishment of wine-making in the two chief centres devoted to it in the Colony. Although there are very large areas of land in New South Wales pre-eminently suited for the growth of the grape-vine, the wine industry has established itself on the Murray and the Hunter, whilst it has nearly died out in its earliest home—the valley of the Nepean. The climatic conditions of the Murray are such as to facilitate the production of rich, luscious wines, not necessarily highly alcoholic but frequently so, whereas the Hunter wines are moderately alcoholic and of a Burgundy type for reds, and the whites are allied to choice growths of the Rhine. Two climatic factors determine the character of wine, apart from those communicated by varieties of vine, culture, soil, and manufacture. Sunshine to thoroughly ripen the grapes producing sugar and rain affecting the density of the must. Vineyards in the interior of the Colony are sure of glorious sunshine during the ripening period, whereas those near the coast enjoy more rainfall at the season when most needed for producing lighter qualities. The sunshine concentrates the juices and brings out the natural flavours of the grape-skin that are so highly prized by connoisseurs. It is the certainty of this brilliant sunshine over the whole of the wine districts that constitutes the most valuable feature in our wine prospects, in that wines over large areas will, each year, be endowed with those choice qualities that are only acquired during exceptional years in the European wine countries. In the sale of wine it is quality that tells, and with such favourable climatic conditions the future of the industry is assured. The following dates refer to the year of the introduction of various grapes, and the names in brackets of the importers :—

	Year.
Small Black Cluster or Burgundy	1814
Miller's Burgundy	1814
Muscat Noir—Black Frontignac	1817
Gouais	1817
Tinta [A. A. Co.]	1825
Verdeilho of Madeira	1825
Muscat Rouge—Red Frontignac [A. A. Co.] ...	1825
Shepherd's Reisling (raised prior to)	1832
Malbec [D. N. Joubert]	1837
Cabernet Sauvignon [D. N. Joubert]	1837
Verdot [D. N. Joubert]	1837
Sauvignon Blanc	1837
Reisling [Macarthur]	1838

STATISTICS.

The earliest records of the area under grape vines for wine-making in New South Wales are for 1843, when 508 acres were returned. In 1850 there were 1,069 acres; in 1860, 1,583 acres; and in 1866, when Coghlan's Statistics commence, 1,243 acres; in 1875, 3,077 acres; in 1885, 2,405 acres; and in 1895, 4,475 acres. The figures for 1896 are as follows:—Total area under grapes, 7,519 acres; for wine-making, 4,390 acres; yielding 885,673 gallons of wine.

If we compare these figures with the world's production of wine in 1895 of probably 2,600 millions of gallons, the quantity is not worth talking about. France alone produced 1,000 millions gallons in 1896, the greater part of which (90 per cent.) was consumed by her own (36,000,000) people. In 1895 the United Kingdom imported of the world's wines $15\frac{8}{10}$ millions of gallons, of which Australia supplied $\frac{6}{10}$ millions gallons, New South Wales figuring only to the extent of 6,249 gallons. Our total export trade for 1895 was merely 21,557 gallons, so that when the export of our wines is under discussion we may be said to have no export trade, and are scarcely likely to when it is considered that we do not supply sufficient good wines for the local demand which is expanding rapidly. It will be seen further on how certain legislative restrictions hamper the extension of the area under grape vines.

THE PRESENT PUBLIC TASTE.

In the present wine-distributing trade there are various types of customers to be catered for. The public-house interest calls for a full-bodied, deep-coloured, alcoholic red wine, approaching Burgundy in type; also a fortified luscious red to serve as port, and be appreciated by old ladies of the lower classes. The prices are cut too fine for matured wines to be supplied, so that the reds are a blend of coastal with Murray or Inverell wines pushed into consumption at the earliest possible date. The ports are made by arresting fermentation by adding alcohol distilled at the vineyard. The public-house custom for the Burgundy type is limited to the comparative few who call for wine, more as a mark of social superiority than for any real appreciation of it as a beverage, and perhaps for this reason the licensed victualler has been quick to discern that local wines, provided the label is right, may be sold as European. Where Australian wines are stocked by the better class of hotels, the prices they are made generally to bear serve to check consumption. They are, as a rule, of good quality, and more trade might be done but for the restrictive prices, especially when the privileges granted by the State in the license are considered. Fortunately publicans do not hold an entire monopoly

for the retail of alcoholic liquors, else the wine industry would fare badly. The Colonial wine licence costs £5 annually, and carries with it no provision for the accommodation of travellers, as is the case with an hotel license. Of late years these wine licences have increased much in numbers, and include the well-furnished city restaurant, the Bodega or better class wine bar, the mere wine shop, and the disreputable wine shanty where coarse strong wines vie with the sale of illicit spirits. The foreign element from Southern Europe patronises extensively wine shops, and consumes large quantities of fair wines. The city luncheon bars and restaurants have of late given a great impetus to wine consumption by supplying good wines at moderate prices, chiefly by the introduction of the Adelaide "baby" bottle which, to the wine merchant, is a nuisance through the trouble entailed for the least margin of profit. It has, however, served to popularise wine as a beverage, and has led indirectly to an increased family trade. Within the past few years many vineyards of repute have opened depôts in Sydney, but the Metropolitan trade is, after all, not so very elastic, although offering the best market. The expense of conducting so many distributing agencies competing with each other must fall heavily on some pockets, and the burden entailed may open the way to some co-operative effort.

MARKETING THE WINES.

In every locality in New South Wales where wine is made, excellent examples of various distinctive types are produced, so that a single cellar contains several varieties, for each of which a separate market has to be found. The vineyard proprietors try to establish a connection among families far and near, and of late many have opened agencies in the metropolis. Hotels and wine shops are also supplied, both in town and country. Representatives of the wine-distributing houses, chiefly in Sydney, visit the vineyards, sample the wines, and offer prices, reasonable but low when compared with the sums charged the private trade. The first to inspect the new wines are the largest wine firms, who mature their purchases in their own cellars, and the practice is extending with these firms to arrange with selected vineyards to supervise the vintage, and buy the whole make at an agreed-upon price. In common with many of lesser extent the larger vineyards buy grapes from the surrounding district at a price per ton depending on the density of the must. The smaller wine-distributing houses send representatives to bespeak certain casks, and take delivery as their trade requires, so that the wines are matured in the cellars of the makers. Many of the smaller wine houses, and wine doctors (to use an expressive term for those who soften down acid wines with carbonate of potash, add

preservatives, and bring into a sort of drinkable condition wines in various stages of decay) search the cellars just prior to vintage, when the owners are at their wits' end for cask and cellar accommodation, and buy at ridiculously low rates. Buyers for export compete with the large wine-distributing houses for good wine, but as the demand within the Colony exceeds the supply of good wines, wine merchants offer better prices than an export firm can afford. The Corowa district has, of late, benefited in particular from the increased demand for wines, so valuable for blending, and old stocks have been entirely cleared.

EDUCATING THE PUBLIC TASTE.

The use of the wines of the Colony as a beverage has increased of late years, chiefly by the leading houses supplying reliable qualities. The "baby" bottle and the city restaurant have educated a taste for the consumption of wines of the claret type at meals, and the palate has learnt to appreciate the natural and indispensible acidity which not only promotes digestion but slakes the thirst. A habit once formed continues, and he who takes wine at lunch in the city introduces it into his home in the suburbs, and thus it comes to pass that a sure but steady growth characterises the local distributing trade. The conversion of the whole of our population into wine drinkers is, however, a problem not likely to be realised. Colonial beer has too strong a hold amongst the lower sections of society to be ousted by wine, although there can be no comparison between wine in which fermentation has run its course and an unstable beer which too frequently is in a rapid state of decay. A beer retailed at 2s. per gallon (3d. per pint), and containing 8 per cent. of proof spirit, compares with a light wine of 16 per cent. proof sold at 6d. per pint, but the Saxon has an inherited taste for beer, just as the Latin has for wine. The entry of Sydney-made lager bier will, doubtless, chiefly affect the imported beers, and possibly check the rapid increase of the consumption of Australian wines at restaurants, but it is not likely to seriously interfere with the established wine-drinkers. If anything, the competition of Sydney lager bier will serve to keep up the qualities of the wines placed on the local market. The taste for the wines of the Colony has grown in spite of the doctored rubbish and cheap stuff that has all along been forced down the throats of the public. It is the merits of good wines that have extended the local trade, and were it possible to impress upon the palate of the public a standard for quality, the appreciation of the good wines of N. S. Wales would still further increase. The Great Exhibition in London of 1851 established the reputation of Burton bitter beer, hitherto scarcely known, as the standard beverage of the

British middle classes, because the refreshment catering was monopolised by Bass. Millions then first tasted Bass' ale, and liked it ever after. In like manner the N. S. Wales public need to have their own good wines introduced. For instance, the Metropolitan Show of the Royal Agricultural Society offers an opportunity of once a year setting before the public the merits of the wines of the Colony. During the last two exhibitions encouraging efforts were made, but much more remains to be done. The formation of the Central Wine Growers' Association places the interest of the industry in representative hands, but to ensure success at Moore Park money will have to be expended. Might I suggest a strong united effort being made to place before the public at the Royal Show an exhibition of the wines of the Colony, and all the appliances of manufacture and cultivation connected with the industry, together with facilities for tasting wines of superior quality only, utilising the Continental Cafe system, where visitors sit around little tables out of doors if the weather be fine, and sip their glasses at leisure.

THE EXPORT TRADE.

A first consignment of Australian wine—*e.g.*, N. S. Wales—reached London in 1851, amounting to 255 dozen, say, 510 gallons. In 1895, 6,249 gallons were sent. The extension of wine culture in N. S. Wales involves in the near future an export trade which at present is infinitesimal, chiefly because the good wines are all snapped up for the local trade. There are, however, in a large number of cellars, bulks of wine which owners desire to turn into money, but buyers for export reject; and some wine-makers have essayed export on their own account with more or less unsatisfactory results.

The British market for Australian wines is developing on distinct lines. The stronger wines of South Australia and Victoria have been chiefly drawn upon by London houses, who have spent large sums in advertising and building up a connection. The demand has, therefore, developed on lines of body, strength, and cheapness, chiefly represented by full-bodied, dry reds, of deep colour, and about 22 degrees proof spirit, approximating to Burgundy in type. Export buyers offer vineyardists of the Hunter 2s. 6d. per gallon for one-year wines fit to ship, and would take all they could get, the destiny of the Hunter reds being to blend with stronger Australian reds to supply that standard of quality custom has now fixed for the British market.

The problem before the wine-makers of New South Wales, seeing that no export trade exists, is to map out a definite scheme of wine export, and to work steadily for success. Quality and uniformity are essential factors, whilst economy of production

in these days of world-wide competition is of primary importance. If the existing "happy-go-lucky" methods of wine production are to be relied on, then a successful export trade lies beyond our reach. The producers on the Murray should strive to arrive at a standard wine for blending with the lighter vintages of the Hunter, and the two should be matured and married prior to shipment. The economical future is towards co-operation in crushing, cellar work, and blending, leaving the shipment and the English distribution to independent traders, who would buy at the N. S. W. export store. The bar to the realisation of this ideal is undoubtedly financial, for if the industry cannot furnish the requisite capital wherewith to buy grapes, establish wine-crushing cellars, and the export blending cellars, outside capitalists will necessarily expect to reap all the profits they can. Some years ago a proposition based on co-operative lines was placed before the wine-growers of N. S. Wales; but when the financial problem had to be faced nothing was acceptable, hence the scheme lapsed. If the wine industry were to do nothing else, it would make a giant preliminary step towards the success of an export trade were a large proportion of the existing wines in the cellars sent to the still and very many of the casks burnt. In Victoria the State, having stimulated wine farming—*e.g.*, the cultivation of grape vines—by a bonus, is now being compelled either to abandon or complete the "forcing" of a new industry by the dilemma in which the wine-farmers are at present placed, who, being quite unable to find a market for their produce—chiefly represented by badly-made wines—must plough up their vineyards. At the present time the Victorian Government finds itself in a tight place, being confronted with a necessity to either find the finances to market the wines or leave the wine-farmers to a hard fate. If New South Wales has been too slow and Victoria too fast in developing the wine industry, South Australia has worked on other lines not altogether satisfactory. Private enterprise has led to the planting of large areas under grape vines, oftentimes of an unsuitable type, and a great bulk of wine has been produced, but of a character that was foreign to the British palate. Private enterprise did its utmost to develop distribution both locally, intercolonially, and in the United Kingdom; but without costly advertising the British consumer is beyond reach, for the vested interests of wine merchants are hostile to the entry of new wines. The South Australian wine-makers therefore applied to the State for assistance, under the hope that the British wine trade would be attracted by a State guarantee of quality. Wine-makers in the colony were invited to send forward any and every class of wine, provided it passed inspection at Adelaide, for transmission to the London Wine Depôt, where Mr. Burney Young prepared the

arrivals for sale. The trade was duly invited to sample and select; wines were sold in the auction mart, and went at ridiculous prices; but the trade was not to be won by a Government guarantee, and the manager finally made arrangements with the old-established wine house of Blandy & Co. to push South Australian wines under the "Orion" brand. The first questions asked by a British wine merchant is whether repeat orders can be filled, and what quantities can be relied on for the future. Because of doubt on these two points very few, if any, British firms have as yet cordially welcomed Australian wines. Moreover, much depends on the British palate, which is governed by prejudice. A Sydney house recently established an office in London, under a manager educated in their Sydney business, and supplied with their very best wines, the quality of which received the highest praise from a noted London expert. The difficulty of inducing British wine merchants and wine-distributing agencies to introduce a new wine of distinguished merits to their customers could not be overcome. So great is the society prejudice in favour of certain continental wines, that when the Australian wines were placed on a dinner-table under their own labels the critics condemned, but when the European labels were put on the Australian bottles the critics were enraptured. Messrs. Burgoyne and others have, however, captured, at no small cost, a market for Australian wines amongst a strata of society in the United Kingdom entirely new to wine drinking, and the greatest hope of an export trade for N. S. Wales lies in working up to the requirements of this and other enterprising firms. The South Australian London wine depôt has its own lesson to impart, in that there should be one—and one only—depôt in London to which the winegrowers of Australia could consign their wines, where they would be nurtured into proper sale condition, and to which the wine merchants of Britain would look for their purchases. It would in fact become *the* Australian wine depôt, and if the prospects of the expenses being met by commissions on sales are small for many years to come, a federation of Government assistance in support of this depôt would prove in the long run of no small advantage to the colonies interested. I take it that this is the utmost limits to which a Government could be expected to go in marketing wines, and the less the State interferes with the private enterprise of distribution the sounder will be the ultimate trade. It is possible that France might purchase Australian wines for blending, seeing how largely raisins and sugar are used to make cheap wines. The French buyers may be relied on to do a large trade provided price and quality meet their views—and quality comes first. The Eastern trade in wines also lies at the door of Australia, more especially now that freights are moderate; but the European official element is wedded to European wines,

and the native demand has yet to be exploited, besides which California meets Australia in the East just as it does in Britain, and in California economy of production, combined with quality, is studied to perfection.

THE DRAWBACKS UNDER WHICH THE WINE INDUSTRY LABOURS.

The existing Excise, Distillery, and Vine Diseases Acts may be regarded as dead weights upon the wine industry of N. S. Wales. The wine maker is allowed to sell wines in quantities exceeding 2 gallons, and, under restrictions covered by a license, is permitted to use a still not exceeding 50 gallons in capacity, the alcohol produced being available for fortifying purposes only. The antiquated Distillery Act prohibits the use of an economical-sized still at the vineyard, and prevents the establishment of central distilleries on a moderate scale, whilst at the present time there is not a distillery in the colony. The Vine Diseases Act gives power to the State to destroy a vineyard infected with phylloxera without providing a scale of compensation, although the Minister has hitherto exercised an option, and awarded sums quite inadequate. The past has shown that phylloxera may reveal itself in the most unexpected spots; and, as the infected vineyard is destroyed for the benefit of the industry as a whole, the simplest justice is for the Treasury to find funds for a fair compensation. There might be a technical objection taken to the burden being equitably distributed over the population of the colony, in that under the present theoretical scheme of raising revenue nine-tenths of the people, by reason of exemptions, escape what is called taxation. The Excise Act bears with some injustice on wine makers, in that for every office or agency they open off their vineyard an annual license fee of £20 is imposed. If it were not for this, agencies would be found in every town of standing for taking orders and supplying quantities of over 2 gallons; but as it now is, what with the indifference of the publican, the too frequent hostility of the brewer, who controls the publican, and the excessive license fee for agencies and order offices, the wine-growers of N. S. Wales are decidedly handicapped. The production of colonial-made brandy is also to be desired. It is estimated 7,149 gallons of wine alcohol—not brandy—were distilled in the colony, and wholly used for fortifying wines; but owing to there being no proper distilleries in the colony, the cellars of many wine-makers are crowded with wines which should be put through the still. Although a vineyard is permitted a still up to 50 gallons capacity, this is of no avail, seeing that the alcohol cannot be sold. These inferior and decaying wines do but deteriorate cask-stock, and keep the wine doctor fully supplied with material for his injurious trade. The sale of a wine only slightly inferior

injures the public taste: and as a wine on the down grade rapidly grows worse, the wine industry suffers to a very material extent from the rubbish held for sale and put into consumption through the absence of a modern Distillery Act. Bad wine is good wine spoilt, and entails a loss upon its unfortunate producer, all the greater the longer it is kept. Here again, when the Act permits it, there will be a field for co-operation by the establishment of local distilleries to separate the alcohol, and of a central distillery to rectify and make the brandy. Furthermore, were the Distillery Act altered, and a suggestion recently put forth carried into effect, that there should be a remission of excise duty on brandy made from grapes only within the Colony of 5s. per gallon, the expansion of wine farming would take place immediately by the planting of large vineyards of the true brandy grape, the La Folle.

DEFECTS OF WINE MAKING.

The difficulties of making wines in small cellars are so great that a co-operative effort to establish central wine cellars should commend itself to all who are outside the range of existing large cellars that purchase grapes. The first process of manufacture is, in the generality of the N. S. Wales cellars, performed with all due care as to cleanliness, but the ensuing cellar management is where too frequently carelessness comes in. The time to rack, regularity in filling up, the use of suitable wine for filling, and the thousand details of skilled management are all liable to unconscious neglect. The small maker has so many calls upon his time that he forgets and the mischief is done. The cask stock is liable to special neglect until the musty, mousey flavour of decaying wood pervades all the wines of the cellar, and too frequently, strange to say, the proprietor is entirely unconscious of it. The "sour sweet" of careless fermentation is also frequently met with, and is due to the want of means of checking the rapid rise of temperature in the fermenting must. In the brewing industry this control is regarded as a cardinal point of success, and special appliances have long been in use. In the English system of brewing cold water is circulated through pipes immersed in the wort, and under the German plan the whole fermenting chamber is kept at a low temperature by refrigerating machinery. The advanced wine-making establishments of America and some in Europe are introducing artificial cold, but so costly an installation can only come within the range of large and central cellars. Some little stir has been made in the use of pure cultures of wine ferments, also a step in the wake of the brewers, and as in the experience of the latter, the theoretical advantages are not always reaped in practice. The preferable method is probably to carefully pick berries of even ripeness, to cull out decayed and

damaged berries, and to trust to a sound fermentation arising from the natural ferments. The mind of the wine-maker is also exercised as to the choice of woods for the making of casks, but in these days of cheap freights the use of suitable oak, and oak is of various qualities—is placed within reach of all. In South Australia sunken tanks of cement are used, and in Algeria upstanding round vats of cement, spread over iron-wire net, are in favour. The evaporation through porous wood is said to enhance the value of the wines; but the loss is excessive, and adds to the sale price of matured wines. It is worthy of consideration whether the use of an impervious material and the introduction of purified air might not accomplish all the good that is associated with the use of wood.

These, and numberless other questions, come within the province of a college of viticulture, where the wine expert should have at command all the appliances for Œnological research. The time has certainly arrived when the establishment of such an institution should be taken in hand. Its educational value is at the present time essential to the improvement of our wine industry, and its facilities for research are equally needed. Were it situated on a Government reserve, having large areas of land well suited for wine farming, and provided for its own use with only a small vineyard, the State might so arrange as to gather around it numerous private vineyards, whereby it would become a centre of the wine industry, by giving the assurance of success to many who otherwise might not be induced to enter upon wine culture.

PROSPECTS OF THE FUTURE.

The wine industry of New South Wales is capable of indefinite expansion, provided the proper efforts are made to obtain success. At present insufficient good wine is produced for the trade within the Colony, which would quickly respond to the entire production of the 4,390 acres now under wine-bearing grapes, were the wines uniformly good. The public taste, hitherto, has not been fairly dealt with by reason of the inferior qualities forced into consumption, but the appreciation of good wines is now rapidly on the increase. Medical opinion points out clearly the advantage of wine as a beverage in a warm climate like that of New South Wales; but having now to compete with Sydney lager bier, the wines for popular consumption will have to possess not only quality and a moderate proportion of alcohol, but be sold at a price that will compare with the higher class of malt liquors. This attainment of quality as a first consideration is well within reach of our wine-makers, more especially in these days of increased knowledge and improved appliances. Whenever the wines of New South Wales have appeared at International Exhibitions, and have been submitted to the judgment of experts, their

merits have won, in many cases, the highest acknowledgment. Why should not all our wines be made of high quality? Dr. Méran, of Bordeaux, and a recognised French authority, in criticising the wines shown at Bordeaux in 1882, said that "the Australian white wines are generally successfully made, with a good colour, delicacy, resembling often the best dry wines of the Gironde (old Barsac, for instance)." In reference to Dalwood reds he said:—"It is amongst these that there is found the most of the wines resembling the Verdot, which appears to be most likely to blend with our French wines. I prefer, however, the Pineaux, more coloured, more generous, somewhat sweet, making one think, according to the year, of our Burgundy, St. Emilion, or Rousillion. Dalwood seems to have succeeded the best in giving young wines, being very like some very good wines from the Bordelais. If we judge according to his wines in bottles, he (Mr. Wyndham) has also been very successful in producing wines similar to those of the Graves, or rather the Libournais; but they are often too dry, too much discoloured (*e.g.*, reduced in colour), even when retaining some sweetness, and very likely they had to suffer from bad conditions of temperature, want of rackings, &c." This testimony is valuable, because it represents the opinion of the highest wine centre of France. Furthermore, Dr. Méran says: "It is most interesting to state that your Australian wines, whilst wanting the qualities expected from the best wines of France, are by far superior to the common wines of the whole of Europe, and they may rest assured of a great future, if the intelligent owners of your principal vineyards obtain experienced workmen, skilled wine coopers, cellar managers, and men qualified to taste wines, ascertain their defects, and develop their qualities." To obtain wines for exportation to France "you should choose," he furthermore says "rich and well-watered grounds, vine-species of an extreme abundance, such as the *Aramon*, and then produce wines similar to those of Languedoc, Provence, and the north of Spain." With regard to choice wines—*vins fins*—the same authority observes: "For these the selection of vine-species is very important, and I fear you have not been very lucky by giving too great a share to the Rhenish species, nor by cultivating separately each vine to obtain as many qualities of wine as of varieties of grapes, such as the Pineau, Cabernet, Malbec, Reisling, Verdot, Hermitage, Pedro-Ximenes, Shiraz. Such a method is not enough to create Rhenish wines—neither Burgundy nor Medoc. It is of absolute necessity to associate a small number of vine-species, springing, blooming, and ripening together, whose different qualities combine and harmonise to give a wine full-bodied, rich with *saveur*, delicacy, and *bouquet* all at once." The best species cultivated for the *vins fins* of France are "Cabernet, Pineau of Burgundy, Verdot, Malbec (often combined together, according to

the soil, as follows: one-third of Cabernet-Sauvignon, one-third of Malbec, one-third of Merlot). It is also most important, both with red and white grapes "never to omit the adoption of a species which will give to the wine *finesse* and *delicatesse*."

I have quoted these opinions, published in M. Bonnard's able report on the Bordeaux Exhibition of 1882, because they entirely apply to the situation of to-day, and I commend for particular attention the export data in the report. Recently the Department of Agriculture analysed the wines of a leading Sydney wine-house, and a comparison was drawn with Thudichum's table of leading continental wines. As to acidity, the wines of New South Wales were, if anything, less pronounced, and there was noticeable throughout a close similarity. Chemical analysis is, however, not everything, and cannot approach the delicacy of discrimination exercised by an educated palate. Australian wines possess, however, a flavour of their own, and, if made to perfection, will undoubtedly win favour by reason of their inherent merits. In 1895 there were imported into New South Wales 1,017,749 gallons of various spirits, whilst with regard to brandy production it is an anomaly that a single gallon of wine alcohol should be introduced into a country so pre-eminently favoured by Nature for the home of the grape; but an antiquated Distillery Act blocks the way. The suggestion put forth by Mr. C. F. Lindeman, representing the wine industry on the Board of Exports, that absolutely pure brandy distilled within New South Wales should bear a differential excise duty of 9s. per gallon instead of 14s., the present rate, would undoubtedly result in large areas being immediately planted with the brandy grape. The dark cloud of possible devastation by phylloxera is at present met by an Act which offers inadequate compensation, whilst the replacement of the entire vineyard area of the Colony by phylloxera proof stocks only awaits the issue of the stocks now in preparation at the Government nursery vineyard at Wagga Wagga. In California, when every winemaker was working on a lone hand, the industry was in a sorry plight; yet within six months of introducing the co-operative marketing of wines, chaos was reduced to order and a market value was fixed for all wines. The hotel and saloon interest throughout the United States used to ignore Californian wines; but when the wine-growers found money to start a continental wine café in the important towns, the public tasted, appreciated, and compelled the local hotel and saloon keepers to stock the wines. At the present time the Californian wine industry is making a strong effort to obtain a market in the United Kingdom by lavish advertising and moderate prices. In these respects the wines of Australia, with which Californian wines compete, have the priority; and whilst the vast population of North America lies at the doors of California, and may shortly

take all the wines that favoured State can produce, the possibly still more naturally endowed wine areas of Australia will have to look to English and European markets, which, and more especially the latter, may be relied on to take very large quantities of wines, provided they are prepared with scrupulous care and foresight. The requirements of both these markets are fixed, so that all that is necessary is to work up to them. In particular, the Bordeaux market desires a superior type of wine to blend with the inferior wines of Europe, and in the production of this type New South Wales possesses every natural advantage, whilst science, improved appliances, cheap land, and cheap freights lend their assistance to neutralise the disadvantages of a long voyage and more expensive abour.

No. 12.—THE COLOUR OF FLOWERS AND ITS INFLUENCE ON BEE-LIFE.

By Albert Gale.

(*Read, Tuesday*, 11 *January*, 1898.)

The subject that I have chosen for this paper may not at first sight appear to be one so fraught with interest as those you have already listened to. That it is in any way directly associated with agriculture may appear somewhat doubtful. Indeed, the title itself is not a very happy one. The matter that I intend to weave into it, both in warp and woof, may not produce a fabric wholly consistent with the *colour* of flowers and its influence on bee-life.

I am dealing somewhat with the essential organs of certain plants, and the agents employed in their reproduction; and I think as I proceed I shall be able to show that bee-life and blossoms are so closely associated the one with the other that to injuriously interfere with either will at the same time militate against both. Animal life—our lives—cannot exist without the vegetable kingdom, but some members of the latter can live and propagate themselves without the former; whilst there are other forms of vegetable life which would cease to exist if all animal organisms were excluded from them—indeed, some forms of insect life are an absolute necessity in the reproduction of plants. I know that amongst phanerogamic plants there are those that are anemophilous and others that are entomophalous. The former can continue to multiply without insect aid, but with the latter insects are an imperative necessity. Nearly all insects more or less aid in the

fertilising of the vegetable kingdom, but the ravages with the foliage caused by some classes of insects far more than counterbalance the good that they may do.

Pollen is the fertilising and vitalising agent in reproducing and perpetuating all classes of vegetables. It is produced in abundance by all flowering plants, both by those of conspicuous and also those of inconspicuous flowers or blossoms. As a rule inconspicuous flowers are anemophilous, and those of more gaudy tints are sought after by insects. It may not be universally understood that there are male and female elements in the vegetable organisms just as in the animal organism. We know that if the sexes in the latter are always excluded, the one from the other, reproduction is an utter impossibility.

We have control over the sexual intercourse of the domesticated animals. Cattle breeders, sheep farmers, agriculturists, orchardists, horticulturists, and indeed everyone, whether engaged in the culture of the soil or not, thoroughly understand this; but we do not find the same knowledge of the methods of reproduction in vegetable life amongst farmers and others. But agriculturists and those engaged in vegetable culture do not as a rule know that plants are reproduced on precisely similar lines as animals.

Schools of Science are established to unravel the secrets of Nature in the mineral kingdom; anatomical classes are open to students who intend to make a living by operating on other than their own frames, and Veterinary Schools do the same for those who desire to so work on the lower animals. All engaged in the breeding of animals know exactly how to mate so as to produce certain results. Sires are carefully bred, more carefully selected, and most carefully reared. All know, if they take the haphazard chances of permitting animals to breed according to their own will, weedy and valueless ones of no market worth are the result. In cattle they know how to cross-breed their animals so as to obtain the best results for the butcher or the dairyman; or, if it be sheep, they know how to breed for wool or for meat; or if it be horses, they breed for strength or for speed. And all this is done from the knowledge possessed of the procreative powers in both sire and dam. Why is not a similar knowledge applied to fruit or any other crop? Because not one out of a thousand has sufficient knowledge of their occupation to understand that there is a sexuality in plants and that fertilisation is as necessary in plants as in animals.

I said just now that pollen is the fertiliser, and that this substance is possessed by all flowering plants. The one great aim of all vegetable and animal life is to reproduce itself or to perpetuate its species.

Both sexes in all the higher orders of animals possess locomotive powers that enable them to come together at certain seasons for

procreative purposes. At other seasons the sexes studiously avoid each other, and in some gregarious animals they separate and form independent flocks, as amongst yellow hammers, chaffinches, wild American turkeys, and deer.

Locomotive powers in plant life are very rare, and where they possess these powers it is more for the distribution of fertilised seeds than for the purpose of fertilisation. There are exceptions, I know—the *Vallisneria spiralis*, for instance.

The higher order of animals are unisexual; occasionally there are malformations termed hermaphrodites; but in the plant world the higher orders are unisexual, bisexual, or hermaphrodites—unisexual when the male and the female blooms or organs are on separate plants; bisexual when the male and female organs are in separate flowers but on the same plant, hermaphrodite when the procreative organs are both in the same bloom (Laurels, 1st; pumpkins, corn, &c., 2nd; apples, pears, &c., 3rd). Yet, nevertheless, no true flower is hermaphrodite—*i.e.*, not hermaphrodite as the term is applied to the animal kingdom. The staminal and pistiline organs are not abnormal malformations, but both organs are perfect and independent of each other, and as a rule in hermaphrodite plants the anthers become distributive before the stigma becomes receptive, or *vice versa*; or, to make it clearer, the receptive and distributive organs do not mature at one and the same time in the same flower.

From this it will be seen how utterly impossible it is, in the great majority of cases, for the anther, when distributive, to come into juxtaposition with the receptive stigma to effect the necessary discharge of pollen to ensure fructification. I am speaking now only of entomophalous plants.

Oftimes in unisexuals that are entomophilous the staminate plant when in bloom is at a considerable distance from the pistiline; and in bisexuals both genders of flowers mature at the same time but on different parts of the same plants, while in hermaphrodites the sexes may be in close proximity; nevertheless the male and female organs do not mature at one and the same time, then how can these inert beings become impregnated but by an agent other than itself—a foreign agent? In nearly every case the pollen of entomophalous plants is not dry and powdery as in the case with anemophilous blooms, but heavy and highly adhesive. It is this property of the pollen gathered by bees that enables them to stow it away so neatly in their pollen baskets. Its adhesive nature prevents its being blown about by winds, and causes an outside agent necessary to transmit it from the male to the female organs.

Now comes the question, why are bees attracted to blossoms? I mention bees because they are the only insects that gather and store both pollen and honey. Other insects feed on one or the

other or both, but with these it is consumed where gathered—that is, it is consumed on the premises.

I am not ignorant of the fact that the perceptive organs in insects are extremely acute, especially in social bees, and that they can both recognise colour and form. All beekeepers know that when young bees take their first flights how cautiously they survey the landmarks surrounding their habitations, and where large numbers of colonies are kept, and where every hive is the same pattern and colour, how necessary it is, when the virgin queens are taking their nuptial flights, to place distinguishing marks here and there to ensure the safe return of the young queen to her own home. But that bees are led to flowers by the colour they possess, and that certain bright colours—red, blue, purple, &c.—are more attractive to them than paler tints, such as white, yellow, &c., my experience most certainly contradicts. I know that the highest authorities on the subject have written and stated that it is so, and it may appear something like gross presumption on my part to attempt to refute their statements. No doubt some of them have given the experience of observation, but by far too many have been satisfied by stating I was informed by Mr. So-and-So of certain movements in regard to bees and flowers.

Sir John Lubbock, in his work on "Bees, Ants, and Wasps," says: "Most botanists are now agreed that insects, and especially bees, have played a very important part in the development of flowers." . . . . "In cases of brightly coloured flowers the pollen is carried by the agency of insects." "I thought," he writes, "it would be desirable to prove this, if possible, by actual fact. I brought a bee to some honey which I placed on blue paper, and about 3 feet off I placed a similar quantity of honey on orange paper." Why he need to place a *similar* quantity I cannot tell, and why he should have *brought* instead of allowing a bee to find it is a problem I cannot solve. Now comes the question—was the bee attracted by the blue paper or the honey food? I have placed honey in a blue campanula, and many other flowers of both conspicuous and unconspicuous colours. When food is scarce bees will visit any colour; but when it is very plentiful they object to take honey already gathered. Last summer, in my garden, I had a scarlet dahlia in bloom. When it first flowered there was not a stamen present. No bees ever visited it. The plant was afterwards neglected by me, and this neglect caused the stamens to appear and the anthers to develop and the pollen to mature. With this bee-improvement in the flower it soon became a foraging ground for them. Why did they not visit the early blooms? Because there was no bee-food present. And why did they so visit it when the stamens appeared? The flowers were not nearly so conspicuous as the

earlier blooms. But in passing over they saw there was a reward for their labour. Double flowers—I mean flowers in which the whole of the stamens have become petals—are far more showy and conspicuous than single ones, both being of the same variety and the same colour. Bees abhor double flowers, no matter of what colour, but single ones they love; but it is cupboard love, and cupboard love only.

Last September I wrote the following, and it appeared in the October *Agricultural Gazette*:—"Early last spring the white Arum lily (*Arum africanus*) was in bloom, and its white pollen was eagerly sought for by bees. At the same time the broad-beans were in full flower. These, too, were an attractive foraging-ground for the same insects. A little later the peach-trees burst into flower, with the result that the first-named was entirely forsaken, and the latter receiving only an occasional visit. Did the bees go to the peach-tree on account of their attractive colours? Not a bit of it. While the peaches were in flower so were the willows (*Salix babylonica*) just throwing out their catkins. When these two trees, peaches and willows, were in bloom my bees were bringing in pollen of two colours, one creamy-white and the other somewhat of an orange tint. At the same time, in the district where I live there were roses, marigolds, arum lilies, and other attractive flowers in full bloom, but few bees were visiting them. The pollen was coming in from the willows and peach-trees; there was also honey coming in from the latter. The flowers (catkins) on the willows are so inconspicuous that a large number of people are ignorant of the fact that they are phanerogamic; yet they were as attractive to the bees as the gaudy peach-trees. During the same spring, and at about the same time, I visited the Botanical Gardens, and the most attractive beds of flowers then in bloom were the English daisies, pansies, anemones, and the turban ranunculus. Nothing in the Gardens were more showy than the two latter, yet no bee visited them. Near these was a shrub (*Buxus sempervirens*) in which there was a constant hum from the bees. What was the cause? Hidden among the dark green foliage there were hundreds of small greenish flowers, supplying abundance of food. If colour had been the attractive agent, bees would never have discovered their food in the shrub, and they would have sought the showy beds of anemones, &c., in vain; they were double, and therefore there was no pollen food. But who will dare to say the attractive colour was absent? A short time afterwards I saw the *boganvillias* aglow with their showy bracts; they could be seen hundreds of yards away. At the same time the pittosporums were in flower. These latter were so inconspicuous that before they could be detected you need stand directly under them. I visited both—the boganvillias and the pittosporum; in the former there

was not a bee to be seen, notwithstanding their fiery glow, whilst in the latter there was a sound as if a swarm of bees had taken possession of it."

Mr. Baker, of the Technological Museum, informed me that he observed a specimen of *Panax sambucifolius* swarming with bees, although it bears a small, very inconspicuous flower. A fence divided it from an enclosure of brightly-coloured garden flowers, yet these were passed over unheeded. Why did the bees neglect the garden flowers? Because the yield of food was not equal to that in the *Panax sambucifolius.* In none of the cases I have named were the bees attracted by the colours, but by what they could get in the form of food.

Many years ago, when in Cooma, I had a bed of turnips in flower that from daylight to dark were besieged by bees. Suddenly the bees forsook them. I found the cause to be that a small paddock of lucerne near by had been permitted to flower, and the bees had gone thither. Were they attracted by the purple flowers? Not a bit of it. Lucerne, like other trefoils, produce an abundance of bee food, far more than any of the cruciforms, and the bees had gone where they could get the greatest quantity in the shortest space of time. In about twenty-four hours afterwards the lucerne was cut, and the bees returned to the turnips.

Darwin says: "It would appear that either the taste or the odour of the nectary of certain flowers are unattractive to hive-bees or to humble-bees or to both, for there seems no reason why certain open flowers which secrete nectar are not visited by both. The small quantity of nectar secreted by some of these flowers can hardly be the cause of their neglect, as hive-bees search eagerly for the minute drops on the glands of the leaves of the *Prunus laurocerasus.*" The small quantity was the cause, as was the reason my bees left the turnips for the lucerne.

Early one spring I saw bees eagerly working the flower-heads of couch-grass. We all know that the flower of the couch has not an attractive colour. The endemic or native flowers intermixed here and there with them were far more showy. Looking into my bees I found young larvæ were plentiful; pollen for bee-bread was needed. The endemic flowers were producing little or none, but on the couch-grass there was a fairly good supply, and this supply was the cause of their neglecting the brighter coloured blooms for the greenish-yellow flowers of the couch-grass.

Watch a large bed of poppies of mixed colours. No one colour is neglected by the bees. They are as eager to forage in the white as in the red. Poppies are great pollen-producers.

Again Darwin says: "Bees repeatedly passed in a direct line from one variety to another of the same species, although they bore very differently-coloured flowers. I observed bees also flying

in a straight line from one clump of yellow-flowered *Œnthera* to every clump of the same plant in the garden without turning an inch from their course to plants of *Escholotzia* and others with yellow flowers, which lay a foot or two on either side." "In these cases," he continues, "the bees knew the position of each plant in the garden, so that they were guided by experience and memory." Their experience was that the *Œnthera* contained more food, and Nature had taught them that it would be impossible to fertilise the ovaries of *Œnthera* with the pollen from *Escholotzia.*

Darwin on "Self-fertilisation of Plants" says:—"Not only do the bright colours of flowers serve to attract insects, but dark-coloured streaks and marks are often present, which Sprengel long ago maintained served as guides to the nectary." If such be the case, how the poor bees must be troubled to find the nectary in self-coloured flowers. I think we have more unicolour flowers than striped ones. If Sprengel maintained it was so long ago, *then* it may have been so; but I maintain, that *now* in these latter days it is not so.

Grant Allen, in "The Story of the Plant," has written some fanciful pictures on the influence of the markings and colours of flowers and their attraction for bees. I know the work is not a text book. He says:—"The lines or spots so often found on the petals of highly-developed flowers act as honey guides to lead the bee or other fertilising insect direct to the nectar." He then goes on to describe the "so-called nasturtium." "The upper pair (of petals) are broad and deep-lined with dark veins which all converge about the mouth of the spur, and so show the inquiring insect exactly where to go in search of honey. The lower three on the other hand, have no lines or markings, but possess a curious sort of fence running right across the face, intended to prevent other flying insects from alighting and rifling the flower without fertilising it." Now, if any insect, flying, creeping, or crawling, were to enter the nasturtium and rifle the flower of its pollen and carry it to one where the stigma was receptive, and the part of the insect's body with pollen on it came in contact with the stigma, fertilisation would be the result. But why do the markings that converge about the throat of any act as guide-posts to them, while we have so many unicolour flowers that are destitute of such markings—to wit, the whole of the pumpkin family and hundreds of others. Pumpkins, &c., cannot be fertilised other than by insects, and the blooms have no finger-post erected saying, "Here you can get good honey and pollen!"

Yesterday I was watching the bees working the pumpkin flowers, and none of them were at a loss to find the pollen or the nectary. There was no hesitancy. The only finger-post for bees in flowers is the food they contain.

Darwin himself says he is not quite sure that in every case the colour and markings of flowers are for the sole purpose of attracting insects.

I have seen questions something like the following put in agricultural examination papers: "What is the use of colour and perfume in blooms?" Such questions should never be put, when we consider that a large majority of the blooms in agricultural crops are anemophilous, and many an observant student can dispute the fact that colour is the attraction.

What is the experience of bee-keepers this side of the equator as it regards the colour of flowers that are chiefly visited by bees? There is no denying that some of our endemic or native flowers are as brightly coloured as the exotics or introduced ones. Before the introduction of our fruit-trees and highly-coloured garden flowers, the chief honey-gathering social insect was the little native bee (*Trigona carbonaria*), and, therefore, it was the chief fertiliser in Australia.

Darwin tells us that it took ages on the other side of the world for the flowers to develop into what they now are in both colour and form, and the bees centuries of training to adapt themselves to the flowers as they developed.

Space will not let me give Darwin's quotations, but all entomologists and botanists are acquainted with the facts.

The chief honey-yielding plants of this continent are the eucalyptus, pittosporum, and tea-tree families, and all these bear whitish flowers. Our introduced fruit-trees and ornamental flowering plants bear brightly-coloured blooms. In spring time our introduced fruit-trees are conspicuous by the multiplicity of their flowers, and our little native bee as readily finds the nectar in them as our introduced bee, and they cannot have had the ages of experience to guide them.

And does it not seem very strange that our hive bee, upon its introduction here and before it had been sufficiently colonised, should have forsaken the bright-coloured flowers of the Old Land that were introduced here at the same time they were? Our exotics and our hive bee, as far as Australia is concerned, are coeval. Untold generations of bees had been trained to work blossoms in the land of our fathers, and their experience had most, if not all, we are told, to do with the development of species and the production of the showy flowers we now see around us. But when the hive bee crossed the Atlantic and the Pacific and came here and found they were among their old friends of the gardens, they forsook them and bestowed their attention upon the simple whitish honey-bearing flowers of the Colony a colour that the writers on the subject say they studiously avoid for the more gorgeously-coloured ones their progenitors had been at such pains to produce

by erecting showy flags and sign-boards for the benefit of the bees of to-day, for the purpose of saving them both time and labour.

The hive bee on its arrival here, after having been educated to the high standard it is said to have attained in the old world, works upon, not our introduced flowers of "red, blue, and purple" so much as upon our simple white and yellow ones—so unlike what they ought to have done, according to the education they had received at our antipodes. Is it not queer that our bees should have gone back in their tastes for colours when they crossed over the equatorial line and came this side of the world?

No. 13.—EXPERIMENTS WITH FODDER PLANTS—NATIVE AND FOREIGN

By D. McAlpine, Pathologist, Department of Agriculture, Victoria.

(*Read Tuesday*, 11 *January*, 1898.)

[*Abstract.*]

The seeds of about 120 varieties of grasses and fodder-plants were received from the United States Department of Agriculture, for trial in Victoria, and the seeds of various native grasses from South Australia, so that 140 different plots were sown for experimental purposes. The object of the experiment was to test their growth under different conditions of soil and climate, heat and moisture, but mainly to prove their drought-resisting properties. Only eighty of the varieties germinated, and none of these were native grasses. Twenty-one species supplied from America resisted the drought, and of these seven were conspicuous for their fresh green growth. Out of sixteen fodder-plants not belonging to the grasses, two were found to be suitable and drought-resisting, viz., Hairy Vetch and Much-branched Polygonum. Seven of the grasses were found to be affected with rust, and, curiously enough, none of these resisted the drought.

No. 14.—THE MESQUIT-TREE (*PROSOPIS DULCIS*, BENTH.) AND ITS SWEET PODS.

By THOS. STEEL, F.L.S., F.C.S.

(*Read Tuesday*, 11 *January*, 1898.)

THE Mesquit-tree is an important leguminous tree, a native of certain parts of North and South America. Its value lies in its capacity for flourishing in arid and stony regions, in affording a grateful shade for stock, and in providing a fair crop of sweet, nourishing pods, which are much relished by horses and cattle. It appears to have been experimented with in different parts of Australia, notably in Western Australia.*

The economic value of this plant has been fully dealt with by the late Baron von Mueller,† by L. A. Bernays,‡ and other writers, and the object of the present paper is to give the results of a chemical examination of the sweet pods, the nature of which proved to be interesting and somewhat unexpected.

Mueller states, on the authority of Sievert, that Argentine-grown pods of this tree contain 25 to 28 per cent. of grape sugar, and 11 to 27 per cent. of starch. An analysis of a sample of the air-dried ripe pods, brought from Honolulu, where the tree is extensively grown, and is known as "Aljeroba," and given to me by Dr. J. H. Reed, has proved the presence of nearly 29 per cent. of cane sugar—not grape sugar—together with over 5 per cent. of fruit sugar, while starch is practically absent. This result was subsequently confirmed by an examination of another sample of the pods sent to me from Honolulu by Mr. Ralph Pearson.

For purposes of comparison, the results of a similar analysis of the ripe pods of *Gleditschia triacanthos*, Linné, are placed alongside those of the Mesquit-tree. The *Gleditschia* pods are locally popularly known as "Honey Locusts," and closely resemble those of the Mesquit in composition. The present sample is from a tree growing at Sydney.

* Journal Bureau of Agriculture, Perth, Western Australia, iv, 1119.

† Select Extra-Tropical Plants, 8th Ed., 382.

‡ Cultural Industries for Queensland, 1883, 127.

		Prosopis dulcis Pods.	*Gleditschia triacanthos* Pods (seeds removed).
Soluble in Water.	Cane sugar	28·8	21·0
	Fruit sugar	5·2	5·6
	Other organic bodies (pectin, &c.)...	11·9	16·0
	Free acid, as malic acid	0·4	0·5
	Ash	1·0	3·1
Insoluble in Water.	Fibre, &c.	33·1	35·2
	Ash	2·2	trace
	Moisture	17·4	18·6
		100·0	100·0
	Nitrogen	1·25	1·08
	Equal to protein	7·08	6·75

In both cases the fruit sugar consists of about equal proportions of dextrose and levulose. A fairly large sample of the *Prosopis* pods being available, the chemical identification of the cane sugar was further confirmed by separating and crystallising it, the sugar so prepared being now exhibited.

My thanks are due to Mr. R. T. Baker, F.L.S., for working out the identity of the Mesquit pods; to Dr. J. H. Reed and Mr. Ralph Pearson for samples of the pods; and to Mr. C. B. Brownrigg for the *Gleditschia* pods.

No. 15.—NOTE ON THE CORRESPONDENCE BETWEEN THE RESULTS OF THE CHEMICAL ANALYSIS OF A SOIL AND ITS PRODUCTIVENESS.

By A. N. Pearson, Chemist to the Department of Agriculture, Victoria.

(*Read Tuesday*, 11 *January*, 1898.)

Elaborate descriptions of methods of soil analysis may be met with in various works on agricultural analysis; but those essential facts which bear upon the subject of the correspondence between the results of analysis and of practical cultivation are very rarely published.

When I commenced agricultural work in this country, it was my intention to carry out an extensive series of experiments with a view of gaining some definite facts on this subject, and a series

of experiments was planned and commenced, but owing to various causes had to be abandoned, and no opportunity has since occurred for recommencing them.

In the meantime I need not apologise for offering for publication a short series of facts bearing on this practically important matter. The series of facts is a mere fragment, but is interesting.

In the year 1894 a series of sixteen plots, variously treated, were laid out by Mr. John Goldie, of Port Fairy, and sown with sugar-beet. Plots 3, 7, 11, and 14 were without manure, and received no special treatment of any kind. The yields from these plots were at the rate of 12·86, 12·37, 12·23, and 11·07 tons per acre respectively. After harvest, samples of soil were taken from these four plots, and on analysis of these samples the following results were obtained :—

		Nitrogen.	Phosphoric Acid.	Potash.	Lime.	Chlorine.
				Parts in 100,000.		
Plot 3.	Soil, 0–1 ft. ...	525	113	120	14,030	18
	Subsoil, 1–2 ft..	217	63	243	15,185	29
Plot 7.	Soil, 0–1 ft. ...	463	101	225	15,850	50
	Subsoil, 1–2 ft..	271	91	125	19,920	20
Plot 11.	Soil, 0–1 ft. ...	357	111	128	25,445	23
	Subsoil, 1–2 ft..	270	78	121	28,420	30
Plot 14.	Soil, 0–1 ft. ...	315	124	156	20,920	4
	Subsoil, 1–2 ft..	207	40	226	5,550	19

The most striking of the above figures are the nitrogens of the surface soils. It will be seen that there was most nitrogen in the most productive of the plots, namely, No. 3 ; and there was least nitrogen in the least productive plot, namely, No. 14.

It may be assumed, not unreasonably, that a greater proportion of the surface-soil nitrogen was used by the crop than of the subsoil nitrogen, for the beet-roots would extend through the whole layer of soil, but not necessarily through the whole 12 inches thickness which was taken as subsoil. The main part of the root goes down only 18 inches from the surface ; moreover, the roots grow for a longer time in the soil than in the subsoil. They start their growth in the soil, and take time to grow down into the subsoil ; and moreover, the plant foods in the soil are held in looser combination, and are more readily available than in the subsoil. It is not, therefore, unreasonable to assume that, for instance, in Plot 3 the proportion of the 217 of subsoil nitrogen used by the crop may have been only half the proportion of the 525 of the soil nitrogen used by it ; thus, supposing $\frac{1}{1000}$th of the 525 soil nitrogen were used, we may suppose that only $\frac{1}{2000}$th of the 217 subsoil nitrogen was used.

We will therefore assign half the value to the subsoil plant foods that we do to the soil plant foods, and regard the nitrogen used, or which might have been used, as in the following proportions :—

	Plot 3.	Plot 7.	Plot 11.	Plot 14.
Soil	525	463	357	315
Subsoil	108	135	135	103
	633	598	492	418

In the same way we may regard the phosphoric acid available as being in the following proportions :—

Plot 3.	Plot 7.	Plot 11.	Plot 14.
113	101	111	124
31	45	39	20
144	146	150	144

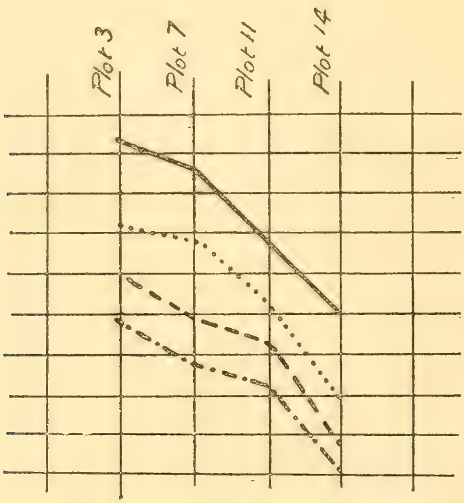
The phosphoric acid at the command of the plants was, it will be seen, practically the same in all the plots.

The results of a number of manure experiments in the soils on Mr. Goldie's farm have shown that the manuring which has the most marked effect on these soils is phosphoric acid manuring, and next to that comes nitrogen manuring. Potash manuring has little or no effect, so far, at least, as the quantity of the crop is concerned. These facts correspond with the results of analysis. Of these three main plant foods the analysis shows the phosphoric acid to be present in least quantity, and in conformity with Liebig's law of minimum—which, though it is not strictly is yet in the main true—we should expect to find this soil respond most markedly to phosphoric acid manuring. As regards the potash, one might, on first glancing at the results of analysis, be inclined to suppose that potash manuring would have more effect than nitrogen manuring ; but it is to be considered, firstly, that most plants make a greater demand on the nitrogen of the soil than on the potash, and secondly, that the potash was in this soil more readily available than the nitrogen, for the nitrogen was present to a great extent in the form of peaty matter, the soil being a peaty, marly, clay loam, whereas the potash was present to a considerable extent in the form of soluble salts. We must therefore consider that the variations in the productiveness of this soil were dependent mainly on the phosphoric acid, and after that on the nitrogen, and that the other constituents were responsible for these variations in a very minor degree.

Let us assume that the phosphoric acid had three times the influence that the nitrogen had; then the total influence would be represented as follows:—

	Plot 3.	Plot 7.	Plot 11.	Plot 14.
Influence of nitrogen in the proportions of	633	598	492	418
Influence of phosphoric acid (3 times the soil phosphoric acid + $1\frac{1}{2}$ time the subsoil phosphoric acid)	432	438	450	432
Total	1,065	1,036	942	850

The figures of these totals are curved in the following diagram, upper curve, continuous lines. The lowest curve—dot and dash lines—represents the production of beet-root in tons per acre. There is a general parallelism between the two lines; but the



parallelism does not continue into detail, for we see that Plot 11 yielded somewhat better than we should have anticipated from considerations of the nitrogen and phosphoric acid only. It will be observed that this plot contained much more lime than the others, and this lime had no doubt a favourable influence on the texture of the soil. If, as in the case of the other constituents, we assign half the value to the subsoil lime that we do to the soil lime, then we get the following figures as representing the total soil and subsoil lime values for the four plots respectively:—

21,622	25,810	39,655	23,695

Now let us assume some arbitrary fraction of these figures, say, for instance, $\frac{1}{500}$th, as representing the favourable influence of the lime on the productiveness of the soil. The above figures divided by 500 are, respectively :—

43 51 79 49

Let these be added to the figures representing the effect of the nitrogen and phosphoric acid ; we thus arrive at the following :—

	Plot 3.	Plot 7.	Plot 11.	Plot 14.
Supposed effect of nitrogen and phosphoric acid	1,065	1,036	942	850
Supposed effect of lime	43	51	79	49
Supposed effect of nitrogen, phosphoric acid, and lime	1,108	1,087	1,021	899

This lowest line of figures is represented in the second curve of the diagram—dotted lines. It will be seen that the irregularity which occurred in our first curve in regard to Plot 11 is now corrected ; but there is an irregularity apparent in Plot 7, which, as seen by the lowest curve, yielded less than would have been anticipated from the influence of the nitrogen, phosphoric acid, and lime, as disclosed by the analysis. I have little doubt that this deficiency was caused by an excess of soluble salts in the soil. That this plot contained more soluble salts than the other plots did is shown by two facts of the analysis : first, it contained the largest amount of chlorine, which was, moreover, mainly in the surface layer ; and secondly, the potash was mainly in the surface layer.

If we assume that any potash in this soil above 120 parts per 100,000 is indicative of soluble salts, we may subtract 120 from the figures showing the amount of potash in the different plots, and we thus get the following :—

Potash, indicative of Soluble Salts in the Soils.

	Plot 3.	Plot 7.	Plot 11.	Plot 14.
Soil	0	105	8	36
Subsoil	123	5	1	106

Assigning, as before, only half value to the subsoil figures, we get the following :—

	Plot 3.	Plot 7.	Plot 11.	Plot 14.
Soil	0	105	8	36
Subsoil	61	2	0	53
Total	61	107	8	89

We take an arbitrary fraction of these figures—say, for instance, $\frac{1}{5}$th—and obtain the following—12, 21, 2, 18, which we may arbitrarily assume as indicating the deterrent or negative effect of the excess of soluble salts, as indicated by the potash figures.

But, in addition to these salts, special consideration must also be given to the chlorides, which have not only the deterrent effect common to all salts—which, in dry seasons, form concentrated solutions in the soil, and thus interfere with osmotic action of the root hairs,—but have also a specially poisonous action, to which many plants are very sensitive. Let us assume that any chloride above 30 may, in a dry season, be accounted injurious. As the surface soil of plot 7 contained 50 of chlorine, there was on this basis an excess of 20. Let this 20 be added to the 21 representing the soluble salts, as indicated by the excess of potash; we then get the figures 12, 41, 2, 18 as representing the deterrent effect of the soluble salts in the four plots respectively. Subtract these from the figures already obtained for the effect of the nitrogen, phosphoric acid, and lime, and we get the following:—

1,096	1,046	1,019	881

as representing the total effect of the constituents disclosed by the analysis. These are represented in the diagram by the bottom curve but one—the dash lines. It will be seen now that even in detail the curve closely agrees with the curve representing the actual productiveness.

Briefly stated, it appears, from a consideration of these facts, that in considering the agricultural value of these soils, as disclosed in the results of a chemical analysis, that the chief weight is to be assigned to the phosphoric acid, in accordance with Liebig's law of minimum, that the nitrogen must receive the next consideration. Minor consideration must then be given to the favourable mechanical effect of the lime in the soil, and to the injurious effect of excess of soluble salts, notably of chlorides.

In conclusion, I wish to point out that this short paper is submitted merely as suggestive. The short series of facts on which it is based are not a sufficient foundation for any general conclusions; nor, indeed, are they in themselves of sufficient importance to justify the rather elaborate treatment to which they have been subjected. The elaboration has been undertaken merely to indicate what, in my opinion, is in general the proper attitude of mind to assume when considering the results of the chemical analysis of soils.

No. 16.—THE ECONOMIC FEEDING OF WORKING HORSES.

By T. U. Walton, B.Sc., F.C.S., F.I.C.

(*Read Wednesday*, 12 *January*, 1898.)

It is a generally accepted principle that, in order to keep a working horse in good condition, a food rich in nitrogenous material must be used, or, as it is sometimes expressed, the "albumenoid ratio" must be high. This ratio is defined as the numerical relation of the digestible nitrogenous matter in the food to the digestible carbo hydrates (including any small quantity of fat, calculated into its equivalent of carbo hydrate, but not including any digestible fibre). Thus a ratio such as 1 : 5 is said to be high, while a ratio of 1 : 12 is regarded as low.

For farm horses, Wolff, the recognised German authority, recommends a daily diet, containing the following quantities of nutriment per 1,000 lb. live weight :—

1·56 lb. digestible albumenoids.

11·19 lb. digestible carbohydates (including 0·5 lb. fat).

Albumenoid ratio, 1 : 7.

When horses are very hard worked, he recommends an increased diet, still richer in nitrogen :—

2·5 lb. digestible albumenoids.

13·8 lb. digestible carbohydrates.

Albumenoid ratio, 1 : 5½.

The object of the present paper is to give a short account of some feeding trials conducted on a very large scale, which prove that at least, under certain conditions, a high diet is not essential to the performance of hard work or the maintenance of good condition, provided sufficient nutritive food be given.

In Fiji, the Colonial Sugar Refining Company have about 1,000 head of farm horses, which until a few years ago were fed chiefly on oats and maize, with some green cane tops in addition. But this did not prove satisfactory in the trying tropical climate. Sickness was frequent, and the death-rate high, while the charge for fodder was very heavy. As large quantities of waste molasses were available, it was thought well to investigate whether the sugar in this material might not be advantageously used as a substitute for some of the starch in the ordinary food.

The ration finally adopted was 15 lb. of molasses, 3 lb. of bran, and 4 lb. of maize per day, with as much green cane tops as the animals can eat, the molasses being mixed with the bran and chopped cane tops, and this has now been given daily to the whole stock of over 400 horses at Rarawai plantation for nearly two years. The result is entirely satisfactory. There has been no undue fattening nor injury to the wind, and no tendency to excessive perspiration or softness.

Sickness, which formerly was frequent, is now uncommon, and the horses are capable of performing harder and more continuous work. The improvement in this respect is so great that while the area of cultivation has been largely increased, it has not been necessary to make any addition to the working stock.

Another important consideration is the financial result. In 1893, with oats as the staple food, it cost £13 3s. per head per annum to feed the stock; in 1897 this has been reduced to £4 2s. 2d., being a saving of over £9 per head per annum. Such a saving, however, has only been possible by reason of large quantities of waste molasses and valueless cane tops being available on the spot. Cane tops cannot in ordinary circumstances be procured for horse-feed by the farmer, though lucerne or any fresh grass is even more suitable. Then, for molasses, which at a sugar-mill has little or no value, a price has elsewhere to be paid to cover the cost of carriage and handling.

According to Wolff, the whole of the albumenoids and carbohydrates in molasses are digestible. Taking Wolff's analyses of bran and maize in the diet that has been described above, but neglecting the cane-tops, would give the following digestible constituents :—

1·02 lb. albumenoids, 12·53 lb. carbohydrates, and 0·19 lb. fat.

Taking 1 of fat = $2\frac{1}{2}$ carbohydrates, and reckoning the average weight of the stock at 1,270 lb., the constituents per 1,000 lb. live weight are—

0·80 lb. digestible albumenoids.

10·24 lb. digestible carbohydrates (including 0·15 lb. fat).

Albumenoid ratio, 1 : 12·8.

The weight of green cane-tops is not exactly determined, but this is about 30 lb. per 1,000 live weight, or 38 lb. per horse. At the same time, the nutriment in this fodder is low, and its albumenoid ratio is only 1 : 9 ; so that any variation in the quantity used has but a trifling influence on the whole diet. Taking the quantity as 30 lb. per 1,000 lb. live weight, this would add to the diet 0·33 lb. digestible albumenoids and 3·07 lb. digestible carbohydrates (including 0·09 lb. fat).

The whole daily ration is then per 1,000 lb. live weight :—

1·13 lb. digestible albumenoids.
13·31 lb. digestible carbohydrates (including 0·24 lb. fat).
Albumenoid ratio, 1 : 11·8 ; also 1·80 lb. salts.

It is thus seen that the full proportion of carbohydrates considered necessary by Wolff for a hard-working horse has been experimentally arrived at in these trials, but that only half the orthodox proportion of albumenoids has been found necessary, and only half the fat. Probably the warmth of the tropical climate renders the smaller proportion of fat sufficient, but the satisfactory results obtained with the reduced proportion of albumenoids prove that the current theory on the matter is erroneous.

The conclusions that can fairly be drawn from the trials that have been made are :—

1. That for working horses the sugar in cane molasses is a satisfactory substitute for starchy food, being readily digested and transformed into work.

2. That 15 lb. of the molasses can be given per day to a 1,270 lb. working horse, with advantage to the health of the animal and to the efficiency of its work.

3. That it produces no undue fattening, softness, nor injury to the wind.

4. That the high proportion of salts in it has no injurious effect.

5. That an albumenoid ratio as low as 1 : 11·8 has proved highly suitable for heavy continuous work when a sufficient quantity of digestible carbohydrates is given.

No. 17.—THE QUEENSLAND TICK: HOW ITS PROGRESS SOUTHWARDS MIGHT BE PREVENTED.

By J. P. Dowling.

(Read Wednesday, 12 January, 1898.)

No. 18.—"THE FARMERS' WEIGHTS AND MEASURES."

By Henry Lord, G.T.C.A.C., Lecturer in Agriculture, Sydney Technical College.

(*Read Wednesday*, 12 *January*, 1898.)

[*Abstract.*]

The farmers' weights and measures (British) are terribly complicated. If a farmer wants to know the price of wheat, he is probably told that wheat is worth so much per *quarter* in London; yet a wheat-buyer comes round and offers him so much per *sack* for his wheat which yielded so many *bushels* per acre, when the seed wheat per acre was only so many *pecks* or perhaps only so many *pounds*. The farmer has so many *miles* of fencing on his farm, most of it put up by contract at so much per *rod* or *pole*, although so many *chains* of fencing he put up himself. The last rainfall gave so many *points* of rain. The farmer's fish-pond (that is, when the farmer has a fish-pond) is so many *fathoms* deep, so many *feet* wide, and so many *yards* long.

The farmer goes on using a large number of units of measure or weight, as shown in the four following lists (marked A, B, C, D,) of weights and measures.

(A.) MEASURES OF LENGTH.

Metric System.		*British System.*	
Myriametre	10000·000	Mile	1760·00000000
Kilometre	1000·000	Furlong	220·
Hectometre	100·000	Chain	22·
Decametre	10·000	Pole, or Rod	5·5
Metre (unit)	1·000	Fathom	2·
Decimetre	0·100	Yard (unit)	1·
Centimetre	0·010	Foot	$0·3333333\dot{3}$
Millimetre	0·001	Link	0·22000000
Metre = 1·093633056 yard.		Hand	$0·1111111\dot{1}$
		Nail	0·06250000
		Inch	$0·0277777\dot{7}$
		Barleycorn	$0·00925\dot{9}2\dot{5}$
		Line	$0·0023\dot{1}48\dot{1}$
		Point	$0·0002777\dot{7}$

(B.) SQUARE MEASURES.

Metric System.

Square kilometre...	10000·
Hectare...... .... } Square hectometre. }	100·
Are (unit) .... } Square decametre.. }	1·
Centiare .... } Square metre ...... }	0·01
Square decimetre... =	0·0001
Square centimetre.	0·000001
Square millimetre..	0·00000001
Square metre =	1·196033292 square yard.

British System.

Square mile	=	640.
Acre (unit) .... } Square ! x ? × x ? }		1.
Rood, = acre	÷	4
Perch, acre	÷	160
Square yard............	÷	4840
Square foot	÷	43560
Square inch	÷	6272640

(C.) MEASURES OF CAPACITY, *i.e.*, volume).

Metric System.

Cubic metre, or kilolitre	1000·
Hectolitre	100·
Decalitre	10·
Litre (unit) .... } Cubic decimetre ... .. }	1·
Decilitre	0·1
Centilitre	0·01
Millimetre .... } Cubic centimetre ...... }	0·001

Litre = 0·22009668 gallon.

British System.

Last (corn)		640·
Wey (corn)...		320·
Chaldron (Imperial)...		288·
Tun (wine)		252·
Butt (wine)...............		126·
Butt (beer)		108·
Puncheon (wine)		84·
Puncheon (beer)		72·
Quarter (corn)		64·
Hogshead (wine)		63·
Hogshead (beer)		54·
Barrel (beer)		36·
Sack (corn)......		32·
Sack (Imperial)		24·
Kilderkin (beer)		18·
Firkin (beer)		9·
Bushel (corn)		8·
Peck (corn)...............		2·
Gallon (unit)		1·
Quart	÷	4·
Pint	÷	8
Naggin, or gill	÷	32
Ounce (fluid)	÷	160·
Drachm (fluid)	÷	1280.
Minim	÷	76800.

(D.) WEIGHTS.

Metric System.

Tonne	1000000·
Quintal	100000·
Myriagramme	10000·
Kilogramme	1000·
Hectogramme	100·
Decagramme	10·
Gramme (unit)	1·
Decigramme	0·1
Centigramme	0·01
Milligramme	0·001

Tonne = 2204·62 lb.
Gramme = 15·432349 grains.

British System.

Ton	2240·
Hundredweight	112·
Quarter.........	28·
Stone.....................	14·
Pound (unit)	1·
(avoirdupois) in grains	7000·
Pound (troy)	5760·
Ounce (troy)...........	480·
Ounce (avoirdupois)..	437·5
Dram (apothecaries').	60·
Dram (avoirdupois)...	27·34375
Pennyweight (troy)..	24·
Scruple (apothecaries)	20·
Grain	1·

Having shown, simply from a farmer's point of view, the absurd complexity of *our* system of weights and measures, or rather want of system in our weights and measures, the questions now arise: What is to be done to simplify them? What do I propose as a remedy? My answer is, simply adopt the Metric System.

No. 19.—FORESTRY IN NEW SOUTH WALES.

By W. S. Campbell, F.L.S., Chief Inspector, Department of Agriculture, New South Wales.

(*Read Wednesday*, 12 *January*, 1898.)

I am pleased to have the present opportunity of inviting attention to the very important matter of forestry in this Colony, for up to the present time, the subject seems generally to have been treated with the utmost indifference, and want of thought by the public.

Strictly speaking, my subject should, perhaps, have been entitled "Forests in New South Wales," for the term forestry, in its general acceptation, may, I think, be taken to indicate the care and preservation of forests; but, as our forests have received but little care or preservation, the term forestry can hardly be said to be applicable to this Colony; at any rate not in the same sense in which it is applied to the scientific forestry which obtains on the continent of Europe (?)—in France, Germany, Russia—and also in India.

Probably but few persons have enjoyed better opportunities of forming an opinion of the condition of our forests, or of our indigenous vegetation, than myself, in the course of my varied duties in the country, and I shall not hesitate in speaking plainly about a few matters bearing on my subject.

In this Colony the settlers, as a rule, appear to have one great object in view, namely, to wage a war of extermination against all trees, in a most thoughtless manner, utterly oblivious to the possibility that their actions may eventuate in disaster. It is unnecessary for me to make more than a passing allusion to similar rash and ill-advised work carried on some years ago in continental countries, which necessitated the expenditure of vast sums of money to remedy the mischief effected, by replanting denuded areas, and the introduction of stringent laws, which are strictly enforced, to protect all forests, and even private forests, over which the owners have but little, if any, control.

In America, thoughtful persons are becoming quite alarmed about the denudation of the country. In a copy of the *Indian Forester*, received by me to day, I find the following quotation from the *New York Tribune*:—"To be able to say that exports

of some leading commodity are now 25 per cent. greater than a year ago, and 100 per cent. greater than ten years ago, is highly gratifying. Yet exceptions to the rule are quite conceivable. If it should appear that the growth of trade in any important product was tending to exhaustion of native resources, and consequent domestic embarassment and disaster, the circumstance would give rise to apprehension, rather than pleasure, and economical wisdom would suggest the direction of efforts toward the restriction of that industry, or toward such modification of it as would avoid the evil results threatened. That is at present the case with the lumber trade. It is a legitimate and important industry, and one which should be so cherished as to insure its profitable permanency. But it is now growing at a rate which threatens in the near future its own self-exhaustion, and the reduction of this country to the deplorable and ruinous state of treelessness. The facts cannot be concealed, and should not be ignored. Throughout all the older States of the Union, forests have long since practically disappeared. Only a few straggling and stunted remnants remain of the superb sylvan growth which once clothed every hillside. The effect is apparent : Streams that once flowed constantly the year round are now overflowing torrents for a few weeks, and dry for months ; springs have dried up ; soil has become arid and sterile ; droughts are more frequent ; agriculture is less profitable. The evils that afflict the treeless countries of the old world are beginning to be felt ; nor are the new States of the far West exempt. Their abundant forests are disappearing like snow in spring-time, and in their place are coming changes of climate, disturbances to the water supply, and the whole train of evils that forest destruction inevitably entails."

Compared with the American forests ours in New South Wales are but a fleabite, and if our export trade of hardwood develops as is desired by some, and when the excellent qualities of our timbers become recognised in other countries, it will take but few years to sweep our forests clean away. The general idea which prevails, that our forests are inexhaustible, is most erroneous. The quantity of really good sound available timber is, in fact, very limited, and it is chiefly confined to the coastal districts, with some few exceptions. The waste by timber-cutters is enormous. If a 30-foot girder should be required, down goes a convenient tree, from which a 40 or 50 foot girder could be cut, and so on. Whilst speaking of timber-cutting, I may mention the great amount of destruction which is caused, very often by the huge dead branches of felled trees. These branches and logs lie against good sound trees perhaps for years until a bush fire sets them alight, when great scars are burnt into the buts of the sound trees, and such a burn will very frequently completely spoil a tree. The scar may be in course of time, and often is, covered over by the bark, but

the injury remains. Bush fires cause an immense amount of damage to forest trees—far more than is generally supposed—notwithstanding their wonderful recuperative powers.

Fortunately for us, the predominating timber trees—the eucalypts—will very speedily reafforest a denuded area, if permitted. The growth of most of them is rapid—some remarkably rapid—and the timber of even the saplings is strong and sound. I have seen eucalypts in the course of fifteen years attain a diameter of 18 inches, and a height of 80 to 100 feet. One of our best timber trees, the blackbutt (*Eucalyptus pilularis*), is remarkable both for quickly re-establishing itself on cleared land if not interfered with, and for its rapid growth. At the same time there are enemies which must be considered when the time comes for steps to be taken to properly conserve our forest areas. One serious enemy is stock. A nibble or two will most certainly affect the growth of a young tree, and cause defects from which it may never recover. To enter fully into these matters would necessitate an altogether too lengthy paper, but I merely mention them to show that to gain a good and perfect "gum-tree" some care and protection may be necessary.

One of the most serious matters to deal with is that of ringbarking. There is nothing to my mind more miserable or more sickening than travelling for miles and miles through dead ringbarked timber. Very often there is not a single living tree permitted to remain as shade or shelter for stock. In such country oftentimes circular tracks may be seen round the butts of the dead trees, made by the wretched beasts following the scanty shade from the broiling rays of the sun. During a severe drought I have seen hundreds of sheep dying in the blazing sun, without a single shady spot which might ease to some extent their agony. It seems to me absolutely wicked for men to ruthlessly destroy every living tree for the sake of a little grass. A certain proportion of forest to area held should be preserved, and this should be enforced by law, as is the case, for instance, in Russia where, I think, the proportion is about 5 per cent.

The necessity for preserving large areas of the existing forest in our dry western districts seems to me to be a matter of the very greatest concern, not only to the western country but also to the whole of the colony. I cannot but think that in the event of the destruction of the forests there our climate may be affected to a considerable extent, and our hot blasting winds will become more severe and more injurious. On the open treeless plains I have observed the destructive effects of wind on the soil. Small cyclones may frequently be seen whirling and sweeping along, tearing up the surface soil to a depth of some 3 or 4, and even sometimes 6, inches, carrying it along in thin high columns, called "booroomuggas" by the blacks. When these winds sweep and dance about,

unchecked by any timber whatever, goodness knows what the results will be. A short time ago I noticed in Riverina a remarkable example of the effects of wind on an extensive open plain. Near one extremity of the plain a wire-netting rabbit-proof fence had been erected five years ago. The fence was not visible when I was there, for it had been covered over by a triangular mound of soil, and was consequently absolutely useless for the purpose intended. Five years prior to its erection in its present position it had been put up a short distance away, with the same result that had again come about. It will not be shifted again, but the soil will be dug or ploughed away. The wire netting had caught dead grass and rubbish, and this prevented the soil from blowing through the meshes. I observed another curious effect in consequence of the accumulation of soil, and this was the formation of a swamp on land that used to be perfectly dry.

In the same district I noticed the remarkable beneficial effects of a plantation—a belt—of shelter trees, chiefly pepper-trees (*Schinus molle*). These trees were about from 15 to 20 feet in height only, but they effectually sheltered an extensive area from a strong wind which was blowing at the time of my visit. The sudden change in driving from almost a tempest to a dead calm was very marked.

In the most beautiful timbered districts in this colony—about the Richmond and Tweed Rivers—the settlers are carrying on the most reckless destruction of the splendid timbers which thrive to perfection there. Millions of feet of such timbers as the Blackbean (*Castanospernum australi*), the Rosewood (*Dysoxylon Fraserianum*), native-beech (*Gmelina Leichhardti*), silky oak (*Grevillea robusta*), and others, are burnt to ashes and utterly wasted, and magnificent trees are being swept away. It will be difficult to preserve any of this timber, or retain reservations, owing to the remarkable fertile soil and its value for agricultural purposes, and the great demand for land for settlement. However, the value of the timber, and the value of the trees for shelter purposes, may possibly become recognised before they all disappear. For instance, a short time ago an intelligent farmer there informed me that he had purchased a block of timber land near his farm for the sole object of preserving the trees. When he told me this I asked him to shake hands, for I honour that man more than I can say.

It would not be difficult to give numerous instances of the evil effects of thoughtless clearing or ringbarking. All those persons who settle on the land should think well before they meddle with a single living tree; but I fear it is of little use preaching this warning. Such is my experience, and not until the mischief has been completed will the effects of injudicious destruction be realised.

3 P

No. 20.—FARMERS' INSTITUTES.

By Walter S. Campbell, F.L.S., Chief Inspector, Department of Agriculture, N.S.W.

(*Read Wednesday, 12 January,* 1898.)

[*Abstract.*]

Mr. Campbell is greatly in favour of Farmers' Institutes, and graphicly described the benefits of the bringing together of the farmers and the talking over of their various practical experiences, which must be highly beneficial to all concerned. He pointed out that it must be patent that the advances made in the science and practice of agricultural and horticultural pursuits have been most remarkable during the last few years. Old practices that have obtained from time immemorial are giving place to new and improved methods, for the farmer and horticulturist is enabled to base his work on sound principles and act accordingly. Mr. Campbell urged that the necessity for improvement is thoroughly recognised by the governments of all civilised nations, for it is beyond question that the welfare of the people depends to a vast extent on skill and industry, and that the very best use shall be made of the land through the liberal diffusion of knowledge. The paper concluded by asking all to render what assistance they could in the formation of Farmers' Institutes.

No. 21.—NOTES ON *EMEX AUSTRALIS.*

By R. Helms, Biologist to the Bureau of Agriculture, Western Australia.

(*Read Wednesday, 12 January,* 1898.)

Although the flora of South Africa and Australia has many genera in common, and even a number of identical species occur in both countries, still from the outset it was doubted whether *Emex australis* was an indigenous plant of Western Australia, whence first it was recorded from our southern continent. The foremost Australian botanists, Bentham and Baron v. Mueller, were uncertain on this point; and whilst including the plant in their works on our flora, they considered it a probable immigrant.

Bentham remarks about the plant: "Besides the Australian species, which is identical with a South African one, and probably introduced from thence, there is one other closely allied to it from the Mediterranean region of the northern hemisphere." And regarding its distribution he notes it as follows: —"South Australia, near Adelaide, and Holdfast Bay: F. Mueller; Western Australia, Drummond 2d coll., n. 290. Preiss., n. 1895."

Baron v. Mueller in his "Second Systematic Census," published in 1889, quotes the species from Western Australia and South Australia but adds "perhaps immigrated."

The aim of these notes is to prove the correctness of the opinion instinctively held by these scientists, which aim, it is hoped, may serve as a sufficient excuse for their production.

The genus *Emex*, was established by Necker from the Mediterranean species, *E. spinosa* in 1790, at that time probably the only species known. Our *E. australis*, it seems, was not determined as being specifically different till 1839, when Steinheil described it in the Ann. des Sc. Nat. It would appear from this late record that, through the similarity of the two plants, their differences have escaped observation for a long time, for it is unlikely that the common South African plant should not have been brought to Europe previous to 1839. Almost at this date, or soon after, the plant must have been sent by Drummond from Western Australia, as will be shown presently.

The fifth volume of Bentham's "Flora Australiensis" was published as late as 1870; but the occurrence of *E. australis* in Australia must have been known to many European botanists previous to this date, as Baron v. Mueller found it shortly after arriving in South Australia, where he landed in 1847. Bentham quotes several authorities, who undoubtedly described the species from Australian examples:—Mig. in Pl. Preiss, 1,625; Meissn. in Linnaea, XXVI, 363; *E. centropodium*, Meissn. in Linnaea, XIV, 490, in Pl. Preiss. II, 273, and in D.C. Prod., XIV, 40.

Regarding the date at which the plant was sent by Drummond to Europe some uncertainty exists, but it must have been during the early forties, as is shown by the following abstract from the first vol. of "Hooker's Journal of Botany," published 1849:—

SWAN RIVER BOTANY.

[It is long since we have given any account of Mr. James Drummond's excursions in Western Australia. We shall here, and in our future numbers, give extracts from his many letters now before us, written during the year 1844, and since, from the Swan River colony.—Ed.]

Hathornden Farm, Swan River,
February 21st, 1844.

"I HAVE just returned, after a three months' expedition, in which I have examined part of the country about the Beaufort and Gordon Rivers and the district south and east of King George's Sound, as far as the Prorongarup range of hills and Mount Mary Peak. On my return I received your letter by the "Ganges," and I beg to offer my best thanks for your remarks upon my collections of dried plants. I am sensible that they are not so well preserved as I could wish; but the fact is, that I have been cultivator for many years ere I gave my attention to the process of preparing specimens for an herbarium; and had it not been for the encouragement you obligingly held out I should never have made the attempt, &c."

The introductory remarks of the editor show that some letters of Drummond had been published prior to 1849, and as this note appears in the first vol. of the Journal of Botany the same editor must have supervised a publication preceding it, of which that publication is a sequence: and from the correspondent's words it may be gathered that he had sent some collections of dried plants before 1844. Consequently the second collection referred to by Bentham as containing *E. australis* was probably sent a long time previous to the date of the letter quoted from, because in those days the sailing vessels often spent six months and more on the voyage between Europe and Western Australia, and a longer time still on their homeward passage, as this was never direct. Moreover, but few vessels were then engaged in the Western Australian trade. At all events it is safe to surmise that his second collection was despatched by Drummond before 1842.

Mr. James Drummond arrived in Western Australia on the 6th June, 1829, by the "Parmelia," the first vessel despatched from England with emigrants to form the new settlement at the Swan River. In the official list he is quoted as "agriculturist," and under Captain Stirling, the Lieutenant-Governor, who arrived in the same ship, he laid out the gardens about Government House. How long he remained in the position of head gardener I have not been able to ascertain, but probably not more than six or seven years, when he settled on some land, as is shown by the address of his letter.

Drummond, without doubt, possessed a good knowledge of plants, and that he largely contributed towards the elucidation of the Western Australian flora is proved by a glance through Bentham's work. When referring in his letters to indigenous plants, he frequently discusses their peculiarities, and their toxic or other qualities, and proves himself a keen observer; and it is strange, therefore, that he should have omitted to mention

the introduction of *Emex australis* into Western Australia, the knowledge of which could scarcely have escaped him.

It may, however, be possible that he did not know of its introduction, or that his remarks on this subject were lost; yet it remains a fact that the plant was deliberately introduced into Western Australia from the Cape of Good Hope as a culinary vegetable when Drummond was head gardener with the Governor, and that its uselessness as a food plant, as well as its objectionable nature, became rapidly known throughout the small settlement at that time.

The information on this point is gathered from the lips of Mr. D. Wonsborough, who is one of the very few remaining survivors of the earliest settlers at the Swan River. As his story is, besides, an interesting reminiscence of the infant days of this vast territory which, during the past few years, has attracted the attention of thousands and increased its population lately as rapidly as formerly the influx was slow, I will give it in full and in his own words:

"The offer to make land grants at the rate of 40 acres for every £3 capital invested in the settlement of the country (stock, implements, tools, goods of every description, cash, &c., purchased the land at that rate) induced Mr. Wm. Tanner to charter a vessel and load it for the new settlement. I was newly married and engaged myself, like several other families, to come out with Mr. Tanner, and signed contract to serve him for five years at cultivating the land in the new country. We left Bristol in June, 1830, in the well-fitted barque 'Margaret,' but through bad weather encountered in the Bay of Biscay a considerable portion of the stock was lost, and after a protracted voyage reached the Cape of Good Hope early in October. Hearing at this place very discouraging news about the newly formed Swan River settlement, Mr. Tanner resolved to abandon his plan of proceeding there and sold the remainder of his stock, together with agriculture implements, of which he had brought a splendid assortment, and vehicles, as well as nearly the whole cargo. The greater part of the goods, &c., were sold by auction at a considerable loss on the first purchase money, and the 'Margaret' proceeded to Mauritius to load sugar.

"We stayed about seven weeks at the Cape, during which time the Scotch barque 'Drummore,' bound for Freemantle and Tasmania, put in for water and provisions. In consequence of this event, Mr. Tanner resolved to take passage to Tasmania, with the view of settling there, and offered to take those along with him who liked to come, or had not found work at the Cape. The most of us acquiesced in this new arrangement. Mr. Tanner then reserved of his goods that had not been sold, and purchased other things back before we embarked. After leaving the Cape

we called at Mauritius for water, and sailed thence on Christmas Day for Freemantle, which was reached on the 2nd February, 1831. On arriving here, Capt. Stirling, the Lieutenant-Governor, managed to persuade Mr. Tanner to stay in Western Australia, and by this means we after all remained at our original destination.

"In the course of time Mr. Tanner found that things did not prosper quite as well as he had been persuaded to anticipate, and consequently I found no difficulty in having my agreement with him cancelled. After working for some time under Mr. Drummond, at the Governor's garden, and for different other people, I entered the services of Mr. J. Phillips as gardener, and lived with him for several years at his place on the Canning River, which is a tributary of the Swan. Whilst in this occupation, I sowed, in the spring of 1833, a bed with 'Cape Spinach,' the seed of which had been obtained from Mr. Tanner, and brought by him from the Cape. This Cape spinach was no other than the plant now well known as 'Doublegee,' or, as we in the early days of the settlement called it, 'Tanner's Curse.' It was given this name by the settlers on account of the annoyance the spinous seeds caused to the labourers. The weed spread very rapidly, and at every turn interfered with our work. The seeds even fastened to the staves of casks that had to be rolled up the banks of the river, no wharfs or similar accommodation being known then, and pricked the hands and arms of the workmen; to bales and other goods it stuck still worse, and in the field it was a constant nuisance.

"The spinach did not prove very palatable, and was never sown by me again, but others may probably have done so before its uselessness became generally known and the plant acknowledged a thorough nuisance. Its offensiveness is not so apparent nowadays as in the early times, when everything had to be done by hand, and without the appliances now in use. In those days it became generally known in the small settlement that Mr. Tanner had brought the seed from the Cape as that of a reputed culinary vegetable; and although he made this mistake unwittingly, his name remained attached to the weed among the old settlers."

The foregoing conclusively proves that *Emex australis* is not indigenous to Australia.

SECTION H.

ARCHITECTURE AND ENGINEERING.

PRESIDENTIAL ADDRESS.

By A. B. MONCRIEFF, M. Inst. C.E., M. Am. Soc. C.E., Engineer-in-Chief, Railways and Public Works, South Australia.

(*Delivered Friday*, 7 *January*, 1898.)

NOTES ON SOME RECENT ENGINEERING EXPERIENCES.

HAVING this year been elected to the Presidency of the Engineering and Architectural section of the Association, I desire to express to this meeting my high appreciation of the honor so conferred. Privileges carry with them responsibilities, and the presidency of Section H is no exception to the rule.

The onerous duties of directing the affairs of a large department, especially during the closing weeks of a session of Parliament and in the middle of an Australian summer, leave little time for the preparation of an address worthy of the occasion which has brought us together. To deal exhaustively with any special subject is, therefore, out of the question; that must be left to those whose leisure yields them the opportunity which some so ably use to the advantage of the profession. To attempt a general description of engineering progress would be but to furbish up gleanings from the scientific press, which of recent years has kept all reading men so well informed in regard thereto. Therefore, the only course open to me is to lay before you notes on some recent departmental engineering experiences in which I have been personally interested, the records of which have not appeared in the public prints, and which—but for this opportunity—would in all probability remain concealed in the archives of the department. It is with the hope that details of some difficulties, successes, and failures which have proved of importance in South Australia may prove of value as helps or warnings to my professional friends elsewhere that I venture on this short address.

During recent years, there has been a very decided change in South Australia in the methods of carrying out our public works; the alteration has now developed beyond the experimental stage and become, apparently, a permanent arrangement. Formerly, we made our designs, drawings, and specifications, and called for tenders from responsible contractors for carrying out the work in accordance therewith, the superintendence alone devolving on the department, and the commercial profit or loss falling to the share of the contractor. Recently—for political, social, and commercial reasons into which I cannot now enter—the large contractor has been practically eliminated, and the duties which devolved on him have now to be undertaken by the engineering officers in addition to those of designing and inspecting. This does not refer to so-called "relief works," which must always stand alone, and of which we have, fortunately, but little experience; nor does it refer to maintenance of existing appliances, but to the larger engineering works necessary for national development.

The Government engineer is thus placed in an entirely new position. Upon him devolves the choice of workmen and the deciding of their rates of wages, consideration of the commercial questions involved in the purchase of materials, shipment and storekeeping, the carrying out of a complicated series of piece-work and petty contract arrangements, the whole being subject to criticism on the public press which was unheard of when the contractor dealt with these matters. He is also hampered by a series of regulations, which seem to him as if constructed for the purpose of hindering his work.

Ultimately, most things resolve themselves nowadays into a question of cost, and the new development of Departmental *versus* Contract work must be prepared to stand or fall on application of the commercial test. How, then, do we stand in this relation?

Generally, we proceed as follows:—A large work having been decided on and the money provided under Parliamentary vote, the working designs are prepared and a brief specification free from legal technicalities is drafted. This latter is really only a description of the work, the printed volume of Standard Specifications being referred to by numbered paragraphs only. Materials which have to be imported are either indented for or procured through local merchants subject to inspection abroad, and no rejection is possible in the Province if the articles inspected have been subsequently identified at port of shipment unless there has been fraud. Workmen are engaged at wages which range from 5s. to 7s. per diem, varying with the locality and the character of the work. Simple work is occasionally done by the piece, the men taking their own time and coming and going as they please. The better class of work is done by petty contract, when one man or a number of men together take up the work in definite quantities

to be completed in definite time, but without money deposit, subject however to retention by the department of 10 per cent. of wages earned as security, payments being made fortnightly. The pay of superintending officers varies from £300 to £400 a year for Engineers, from 14s. to 16s. per day for Inspectors, and from 8s. to 12s. per day for Foremen. The Permanent Staff receive the usual Government holidays, but the Temporary men do not. These methods have been applied in numerous instances and to a large variety of works, including Railways, Waterworks, and Manufacturing.

About 350 miles of railway have been constructed during recent years departmentally, the latest instance being the Blyth and Gladstone Lines, about 56 miles long, the permanent way and plant and tools being bought by the Department, the live stock, labour, and vehicles, such as drays, being supplied by the local farmers, the earthwork, masonry, provision of ballast, sleepers, bridge-work, fencing, and construction generally being carried out on one or other of the methods described, with the following result:—

The estimate prepared for the construction of the line without rolling stock was £246,000. The actual cost of the completed job was £210,000. The detailed items can be given on schedule, and is available for those who are interested in such matters.

This line is one of our best, and has given no trouble since construction.

There is at present on hand a large reservoir for the supply of water to the Port August District, and the whole work is being done departmentally, the estimated cost being £63,000.

But the large works estimated to cost £509,000, and for increasing the supply of water to the city of Adelaide, is an example of the use of the two methods of construction in their transition state. The two long tunnels, one about 3½ miles, and the manufacture of the leading mains were let in contracts, and the remaining work, embankments—one 80 feet high and ½ mile in length—drains, intakes, road, forming, fencing, &c., were done departmentally. No doubt the whole work, if carried out some years ago, would have been let to one large contractor. The combination of the two methods in this instance is but an indication of the tendency referred to above.

The total cost has been £492,000, and a complete schedule of the cost in detail is available for any who may feel interested in long lists of prices.

The full development of the departmental method is however most marked in our manufactures. We are now making all the cast-iron pipes and practically all the cast-iron and brass work required by the Government. Here a commercial valuation of the change is more clearly possible than in any other branch.

I note for comparison the rates paid under contract for cast-iron pipes from 2 inch to 12 inch in diameter. These varied from £8 15s. 1d. to £10 4s. per ton; whereas the cost of pipes of the same sizes which have been turned out at the Government workshop for the year ending 30th June, 1897, has varied from £5 14s. 3d. to £7 4s. 3d. I find that during this period the average cost of pig-iron was £3 2s. 3d. per ton, and that for every 5s. per ton rise in price in the cost of iron it makes a difference in cost of 5s. 3d. per ton in the cost of the finished article. The lowest price at which I have been able to obtain coke has been 35s. per ton, and every 5s. rise in price of that material makes 1s. difference per ton in the cost of the finished pipes.

To enable comparison to be made with the cost of similar work elsewhere, I may state that moulders receive 8s. and 9s. per day; fettlers, 8s.; testers. 7s.; and labourers, 6s.; and working out the proportions of the cost of various materials in 1 ton of pipes at average prices, I find that the cost of iron is £3 4s. 9d.; coke, 6s. 10d.; labour, £1 16s. 10d.; sundries, 4s. 3d.; shop charges, 11s. 1d., making a total of £6 3s. 9d., which is the average cost of the pipes recently turned out.

It may further be interesting to note that at present prices steel pipes 3-16 in. in thickness are cheaper than cast-iron for all sizes above 15 inches in diameter, whereas if the steel is $\frac{1}{4}$ in. thick it is cheaper to use that material in all sizes of pipe above 17 inches in diameter.

This comparison holds good in the neighbourhood of the sea-board, but would be modified a little when carriage charges have to be added for up-country districts. For instance, I estimate that in laying a 20-in. main there would be a saving of £500 in using $\frac{1}{4}$ in. steel in the neighbourhood of the city, but that there would be a saving of about £700 in using the same material in preference to cast-iron subject to 150 miles of rail-carriage added.

The departmental method has its advantages and its disadvantages. Where there is so much work in the hands of the Government, the labour question, rates of wages, and Parliamentary interference may become serious difficulties. The method is, in my opinion, better for the workmen; but so-called red-tape is a positive hindrance, and always with us. The possibilities of modifying the work to suit developments and change designs as circumstances may demand, without having to consult a contractor's convenience and dread unconscionable claims, is a series of invaluable advantages. Largely increased responsibility is placed on the engineers when they are called upon to carry out what used to be looked upon as contractors' work as well as their own; but, on the whole, I claim that the experiment in South

Australia has, from a social and commercial point of view, been a success. Our work has been more economically done, and I challenge criticism as to its quality.

One of the most important engineering questions which my department has had to deal with in recent years has been the attempt to carry out the very wise and liberal policy of the Government, and answer the demand for "cheap water" for domestic purposes and stock over large areas of dry country. In one district alone nearly 1,000,000 acres have been closely reticulated with cast-iron pipes varying from 2/ inches to 12 inches diameter. Into a history of our progress in water conservation it is not my purpose to enter, but to relate some of our experiences in the use of the cheaper descriptions of reticulation pipes. The instance which I choose as an illustration is a steel main 70 miles in length, 16 inches and 17 inches diameter, formed of riveted plates, and varying in thickness from 1-16 in. to 5-16 in., working under pressures varying from 0 to 300 lb. per square inch. Long lengths of this main are of plates 12 and 14 I.S.G., and the use of such thin plates is, I believe, unique in permanent works. They were manufactured under contract, and have been in use for over three years, and the results are noteworthy.

The coating was of the usual asphalt composition. In long lengths the pipes are as good as when laid, but in some places they have failed, having been pitted from the outside and rusted into holes ; in a few instances, even the heads of the rivets having disappeared. This unsatisfactory result has occurred where the main was laid in damp clay formation. The clay has been found to have an affinity for the asphalt coating, with which it seems to amalgamate, and then by contracting draw it away from the plates, leaving them quite clean and exposed to the destructive action of whatever salts may be in the soil. When these cheap pipes were laid it was recognised that the coating was all important, and to find it thus removed from the steel is disappointing. The pipes laid in limestone or gravelly country are intact, the tenacious clay referred to being the cause of the local failure. There is naturally a popular re-action against the steel pipe as a whole, but to an engineer this is unreasonable. A cement coating has been tried with success on some of these damaged pipes, but is costly in application, and there is no adhesiveness between it and the steel. The cure seems to be the laying of the main coated with asphalt, on a gravel bed, and surrounded with limestone rubble or some other similar material so as to prevent the clay when filled into the trenches from touching the coating. Whether this will lengthen the life of the very thin pipes so as to justify their continued use in new work remains to be seen, and the experiment will doubtless be watched with interest. In the meantime, I am laying no new steel pipe less than 3-16 inch in

thickness. It is worthy of note that the clay referred to has a deteriorating effect on cast-iron pipes also, some of which having been in service for 20 years have been found so changed in character as to be incapable of withstanding even moderate pressures, the material being like plumbago instead of cast-iron, and as easily cut with a pen-knife as the black lead of a pencil. Its action on the coating of the steel pipes seems to be mechanical, but on the cast-iron chemical. In this connection I may say that we are now using galvanised-iron service piping everywhere with satisfactory results as to durability and economy.

Recent experience in deep well boring operations is of special interest in relation to the question of the extent of the Central Australasian artesian basin. The rig known as the drop drill is that almost exclusively in use. The old cable drill was largely superseded some time ago by $2\frac{3}{4}$ inch steel-wire rope, and then the Canadian pole-drill was introduced and used very successfully in some classes of country (the diamond-drill being reserved for boring for minerals). I have found it most advantageous in the new rigs recently constructed to combine the pole and the steel rope so that either can be used as found desirable, and constructed so as to be capable of boring to 5,000 feet; the result, undoubtedly, is the expediting and cheapening of the work.

In this class of work the department provides the outfit and the casing, carries out all the carting, and lets contracts for labour only. There is no class of work in which we are engaged into which the element of chance seems to enter so largely—"Bore out of perpendicular," or "Casing-shoe lost," or "String of tools stuck at 2,000 feet," are examples of the short but comprehensive telegrams often received following a carefully detailed report that all was going well, and the result of the work almost an assured success. All our casing is $\frac{1}{4}$ inch thick, of BBB Staffordshire iron, with what is known as "swelled joint," and varying in diameter from 12 inch to 5 inch, the largest size being always used to start with.

Upon no subject have more erroneous notions been promulgated than in connection with deep well boring. The popular idea seems to be that a successful result in the obtaining of an artesian supply can be assured anywhere if only the bore is put down deep enough.

That money has been wasted, through pressure brought to bear, in carrying out this idea is undoubted. In many instances we can only cover up the failure by saying that the bore was put down for experimental purposes, whereas if the voice of scientific reason had been listened to the money would have been saved, and the discredit avoided. It is still popular to reply, "You did not go deep enough," even to such a statement as this, and although the work may have ended in many feet of solid granite.

The artesian basin, which occupies such a large portion of the provinces of Queensland and New South Wales, extends also into the north eastern corner of the province of South Australia and the south-eastern corner of the Northern Territory. On the map the provincial boundaries appear to divide it into four portions of approximately 374,000 square miles in Queensland, 60,000 square miles in New South Wales, 110,000 square miles in South Australia, and 42,000 square miles in the northern territory. Geologically I believe it stands as a whole, and constitutes one of the largest and most remarkable artesian basins known.

Scientists, of course, desire to study this basin in its geological aspect, and a brief reference to the borings by which our portion is being exploited by my department will supply the South Australian contribution to the mass of interesting facts which are being gathered concerning this wonderful natural storage of water.

There is abundant evidence which may be cited in proof of the contention that the marine shale beds under which the water is found in South Australia correlate with those of the portions of the basin within Queensland and New South Wales. Many of the fossils have been determined as identical, and further proof is coming to light almost every day. From a boring in progress at Dulkaninna, in South Australia, and from a depth of 1,166 feet, an interesting fragment of a large ammonite has just been found, which is no doubt identical with ammonites daintreei of the Hughenden beds, Queensland, and which has been figured by Mr. Jack, the Government Geologist, Queensland, and R. Etheridge, Curator of the Australian Museum, Sydney, and determined as of lower cretaceous age ; therefore, without doubt, to this age may be referred the whole of the shale beds in South Australia and the northern territory, under which is found such a remarkable and splendid supply of artesian water under hydrostatic pressure sufficient to bring it over the surface. So far as these strata have been proven, their thickness ranges from a few feet on the edge of the basin to 3,000 feet at about 100 miles northwards towards Queensland. There is every reason to suppose that about the boundary line between Queensland and South Australia, in the neighbourhood of Birdsville, the thickness of these strata will prove to be nearly if not quite 4,000 feet.

In South Australia seventeen Government borings have been put down within the area of this secondary basin. Towards the edge of the basin the depths range from 228 to 365 feet, and from some of these comparatively shallow borings the daily flow reaches a maximum of $1\frac{1}{4}$ million gallons of water at a temperature of about 96 degrees Fah.

The shale-beds thicken rapidly as the shore line of this old cretaceous sea is left, and at 30 or 40 miles the borings have

penetrated to depths ranging from 1,360 feet at Lake Harry, where the water has a temperature of 116 degrees Fah., to 1,571 feet at Oodnadatta, where the water has a temperature of 113 degrees Fah. The supply from such borings reaches 100,000 to 270,000 gallons per diem, and the quality thereof is distinctly better than that from the borings nearer the edge of the basin. One of the last borings completed is that at Kopperamanna, about 100 miles from the edge of the basin. This is the deepest boring in South Australia, and the artesian water was reached at 2,874 feet, and the supply quickly increased until at a depth of 3,000 feet the flow over the surface reached 800,000 gallons of excellent water per diem, at a temperature of 176 degrees Fah. The pressure at the surface is about 100 lb. per square inch.

It will thus be seen that within the limits peculiar to this formation successful artesian wells can be confidently predicted, and that as a general principle the depth will depend upon the distance from the edge of the basin.

The height to which the water will rise under its natural pressure—presuming that a tube were carried up above the surface as far as the water will reach—is not one uniform elevation above sea-level. There is a clearly determinable hydraulic grade line with a fall from the direction of the source of about 9 inches per mile. Speaking generally, the chief source of the water is the coast range in Queensland and New South Wales.

The theory has been repeatedly advanced that there is a deep-seated flow of this underground water in the bed of the sea towards the Great Australian Bight in South Australia. The information so far obtained, however, in South Australia, from numerous borings, is strong presumptive evidence to the contrary, and geologically the Nullarbor Plains formation near the head of the Bight does not correlate with the cretaceous beds, and the specific evidence of several borings within 80 miles west of Lake Eyre goes to show that the edge of the basin may be drawn within this limit, and that beyond it, for a considerable distance, the water is as salt as the sea. So far then, speaking from a departmental standpoint, no connection has been traced, either geologically between the formations, or between the waters of this artesian basin and the waters towards the Great Australian Bight.

Numerous Government borings have been put down in South Australia to depths reaching to 2,000 feet outside the secondary basin referred to, but with only moderate success. In only three instances in such bores has artesian water flowing over the surface been discovered; in some others sub-artesian water has been found, but in many only very salt water has been tapped. Almost invariably granite bed-rock or other equally unfavourable conditions have been reached before abandoning an unsuccessful bore.

One of the difficulties which we have lately solved is the rendering of the Port Adelaide River safer for navigation by ocean steamers both by day and night. The distance of Port Adelaide from the sea is about 9 miles, the depth of water being 23 feet at low-water, the width of the dredging 250 feet. The old marks were a series of buoys showing the channel by day and kerosene oil lamps at long intervals for use at night. Recent experience showed that this system of marking was unsatisfactory. All the buoys have been removed and a series of straight lines have been charted, in continuation of each of which is a triangular leading beacon, and at some distance off on the same line is an advance beacon, an inverted triangle; when the two are seen in line the vessel is on the right course. For use at night, each leading beacon is electrically illuminated with a white light, while the advance beacons are similarly lighted in red. So far as I am informed such a series of electrically-lighted beacons for navigation purposes in an important water-way is new in Australian waters; therefore, I have thought that a short description thereof would not be uninteresting.

Eighteen lamps in all had to be lit, the one at the extreme end of the circuit being $8\frac{3}{4}$ miles away from the source of current supply. The first portion of the circuit consists of an overhead wire with short leads of submarine cable connecting it with the beacons in the river *en route*. Owing to the contour of the foreshore, the latter portion of the circuit consists of a submarine cable only, carried direct from beacon to beacon. As power is only available in the day time, it was necessary to make use of a storage battery for lighting at night, the switching "on" and "off" of the lights being performed by the night watchman.

The generating plant consists of a nominal 8 horse-power vertical engine running at 180 revolutions per minute, belted to a shunt-wound dynamo running at 800 revolutions and having an output of 130 amperes at 60 volts; and as 96 accumulators are used in series for lighting, it was necessary to divide the storage plant into four sets of 24 cells each, to be charged in parallel. This is done by a special commutator on the switch-board, a single movement of which places the cells either in parallel for charging purposes or in series for lighting the lamps. For charging purposes each set of cells is provided with a separate ammeter together with a set of carbon resistances so that the charging rate may be kept uniform in each set. It is, however, rarely necessary to use these regulating resistances, as the cells vary but little in their charging rate. A single voltmeter is used which is connected to any set by switches as desired. A polarised cell-coupler is used with magnetic cut-outs on each main from the charging machines. Charging is carried out on every morning except

Sundays, but the capacity of the cells is sufficient in case of need to light the beacons for three nights in succession without recharging.

For the beacon lighting, incandescent lamps of 16-candle power are employed, the voltage of the lamps ranging from 170 to 100 volts with the distance of the beacons from the generating station. The lamps are not allowed to burn for more than 500 hours, being changed when that length of time is reached.

To provide against the extinction of the light in any of the beacons through the failure of an incandescent lamp, a differential relay is placed in each of the lanterns, which automatically brings a spare lamp into circuit immediately the first lamp burns out. As in the leading lights used in the longer reaches of the river the power of the lamps is raised to about 70 candles by means of reflectors and lenses, it was necessary that the broken lamp should be thrown out of position, and the spare lamp brought exactly into the focal point. This is effected by mounting the two lamp-holders on a spindle at an angle of 90 degrees to one another. The extinction of the first lamp releases a trigger, freeing the spindle, which is revolved by means of a counterpoise weight, bringing the spare lamp into position, the circuit for which is completed by the fall of the trigger. A small oil dash-pot connected to the spindle gives it a slow motion, and prevents any jarring of the filament.

For the purpose of checking the working of the lights a recording ammeter is placed in the main circuit, and from the resulting diagram it is possible to ascertain if any lamps have failed during the night, if the second lamp has been switched in, and, approximately, from the deflection of the line, the position of the beacon in which this has taken place. The failures have been very few.

A mercurial contact is attached to this ammeter, which rings an alarm-bell if the current falls below its proper point during the time the lights are burning.

In conclusion, I crave pardon for the desultory character of the notes which I have submitted, but they will serve to show in some measure the trend of our departmental engineering in South Australia, and the details given may be useful for the sake of comparison with those of similar work elsewhere. That the possibility of such comparison may be more assured in the future, I beg to enter a plea for the unification of the methods of preparing estimates for engineering works and keeping the records thereof, especially in regard to the items of cost in the various parts of Australasia.

In preparing estimates, or recording expenditure, I include all charges for carriage, interest on loan during construction, and reimbursements to other Departments, as well as the actual expenditure in money on material and labour. I have found that

some of these items are not included in the records of expenditure in other colonies, and it is therefore most difficult to make comparisons of the cost at which similar work in the various parts of Australasia is being carried out. This is, I admit, a decided disadvantage, and often leads to unjust criticism. Further, my experience points to the fact that the accurate recording of every item, and the careful comparison of the prices of similar works carried out by various engineers, induces a healthy rivalry, which tends to cheapen similar work in the future. Hence my very urgent pleading for an intercolonial method of preparing estimates and keeping records which will be accurate, comprehensive, and uniform, as under such conditions alone can fair and useful comparisons be made.

No. 1—NOTES ON THE PRINCIPLES ADOPTED IN CONSTRUCTING UNBALLASTED LINES OF RAILWAY IN NEW SOUTH WALES.

By H. Deane, M.A., M. Inst. C.E., Engineer-in-Chief for Railway Construction, Public Works Department, Sydney.

(Read, Saturday, 8 *January,* 1898.*)*

So much misconception exists as to the practicability of cheapening railway construction by leaving out ballast, that the author considered the present occasion, when engineers from the different colonies are meeting together, would be a suitable one for giving some information on the subject.

It is clear that cheap railway construction can only be carried out in country the features of which permit of the ruling grade and sharpest admissible curvature being so applied that a minimum of earthworks may result. In the case of the New South Wales Railways, which are all built to the standard gauge, and on which rolling stock of the ordinary English type is used, curves of less than 10 or 12 chains are not desirable, and, in order that paying loads may be hauled, easy grades are necessary. It is evident, therefore, that it is only possible to make a really cheap line in country which is tolerably level, or where the features are so large that, with the permissible grades and curves, the surface can be followed. Did the design of the rolling stock permit of sharper curves being used, the principle of light construction could be carried into country of much rougher description, as the formation could still be kept near the surface.

In 1894, the author visited America, where he saw the principle on which lines were made without ballast, and convinced himself of the practicability of carrying it into effect in this country; he is of opinion that in no other way is success possible, and that it is to the neglect of one or two most important points that previous failures to construct unballasted lines in Australia are due.

The author wishes it to be distinctly understood that he is not advocating the general use of unballasted lines in preference, but he is merely demonstrating the practicability of constructing them where desired economically and with a minimum of maintenance afterwards. There are districts where ballast is not obtainable except from very long distances, and where, at the time of construction, ballast would cost from ten to twelve shillings per cubic yard, and where, therefore, the use of it would, if the lower value is taken and the quantity used is 15 cubic yards only per chain—equal to 1,200 cubic yards per mile—involve an expenditure of £600 per mile for ballast. What an advantage to be gained, therefore, by leaving out the ballast in this case! After all "the proof of the pudding is in the eating," and the test of economica construction is the cost of maintenance, and as some of the unballasted lines only cost about £30 per mile per annum to maintain, it may be conceded that further argument against the principle is useless.

The diagram shows a cross-section of the permanent way and embankment. The following points are attended to:—

(*a*) The formation is kept as low as possible consistent with the rounding required. This reduces unequal subsidence of the embankment to a minimum.

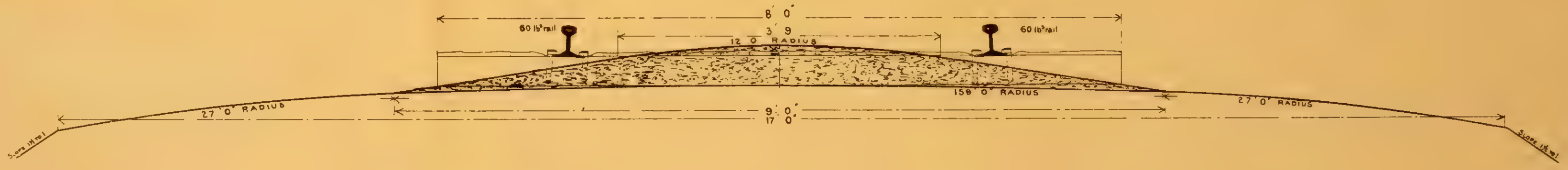
(*b*) The formation is well drained by carrying out the proper rounding and excavating the side cuttings from which the embankment is made in a regular manner so that water may be speedily got rid of. Where possible the formation should be above the surface, and cuttings avoided.

(*c*) Plenty of sleepers should be used so that the rolling load may be distributed as much as possible over the earth formation. The author's usual practice has been to put fourteen sleepers to the 30-foot rail length, or 2,464 per mile; but on the Nevertire-Warren Line, as the country is particularly liable to flooding, there are sixteen sleepers to the rail length, or 2,816 per mile.

(*d*) The ends of the sleepers are kept free so that pits may not form in which water will lodge. To ensure the possibility of this condition being kept up, plenty of rounding to the surface is required, or rather plenty of slope towards the edges of the embankment, so that as the sleepers tend to sink the ends may still be easily freed by clearing away the earth with a shovel.

UNBALLASTED LINES

Cross Section of Embankment and Permanent Way
Showing Use of Earth in lieu of Ballast.



H Deane

Unballasted Railways in N. S. Wales.

By HENRY DEANE, M.A., M. Inst. C.E.

(*e*) The earth ballast is filled in between the sleepers and between the rails, with a slope towards the side so as to throw off the rain-water which may fall on it. Care is taken that the earth ballast under the rail shall not reach up to the flange, so that water may run off freely.

The author is of opinion that if the above points are carefully attended to the principle is one that may be safely adopted in the drier climate of the interior and on lines where the amount of traffic is small. In the coast districts, where the annual rainfall is nearly everywhere heavy, and on lines with considerable traffic ballast should be used. When traffic greatly increases on new lines it would be wise to strengthen them by ballasting, and the additional sleepers which have been placed in the road will be found to make the line easier to maintain, as they give better support to the rails and add weight to the permanent way, making it less liable to lateral shifting.

It has been stated that unballasted lines are a makeshift, and that it is only a question of time when ballast must be laid down, that in America where lines are made without ballast in the first instance, ballasting is undertaken at as early a date as possible afterwards. This is not strictly true—there are lines in America which may never be ballasted because they do not require it. Frequently, however, the ballasting is left out in the first instance because it is cheaper to do it after the line is finished and when it can be ran forward by the trains. The question as to whether ballast should be left out or not must be determined after considering the climate, traffic, and cost of the material. There are some places where it would be folly to leave it out, and others where, in the author's opinion, it would be useless extravagance to put it down.

No. 2.—THE COMMERCIAL CONDITIONS GOVERNING RAILWAY EXTENSION IN AUSTRALIA.

By C. O. Burge, M. Inst. C.E.

(Read Saturday, 8 January, 1898.)

[*Abstract.*]

This paper begins by pointing out the distinction between the conditions governing railway extension where, as in Europe and America, private enterprise prevails, and those involved by ownership of the railways by the whole people, as generally obtaining in Australia and other southern colonies. In the former case, the equilibrium between the receipts of any proposed railway,

from the users in rates and fares, on the one hand, and the working expenses and interest on the capital, on the other, is the only financial question, whereas in the other case, the owners—that is to say, the people of the colony—are at once the shareholders, the general public to be served, the landowners, to some extent, whose property is improved, and the taxpayers who are interested in the increase of population induced by railway extension, such increase always reducing the cost per head of governing them.

The proper way, therefore, to ascertain the commercial value of a proposed railway to be constructed by the Government for the benefit of its people, is first to estimate its cost, including that of equipment, and the value of the land occupied, both public and private, and to put the annual interest on this amount, and the estimated working expenses, on the debit side.

Then on the credit side, should be placed :—

(1.) The present cost of carriage by road of goods and passengers over the length of the proposed line, which expenditure will cease on its completion. This is a credit, for the wealth of a country is the value of its products, less the cost of production, and one of the costs of production is that of transport; therefore, if the transport be cheapened the wealth is increased by the amount of that cheapening. In this credit also should be included the money value of the saving in time of conveyance of goods and passengers.

(2.) The gain to the country, generally, by an additional area being brought within the influence of the railways, leading to increased production, under the economical advantages provided by the connection with the main railway system.

(3.) The increased value to the Crown lands within such influence, or to the natural products thereof, such as timber, &c., &c.; and

(4.) The saving in net cost of Government by the increased density of population induced by the better communication.

It may be said that credit also should be taken for the cost saved of maintenance of roads superseded by the railway, but it has been found in practice, owing to new country being developed with the new roads of access required, that more rather than less expenditure is incurred as a rule for roads, through railway extension.

The same considerations apply to the road transport by horses and waggons, the operations of which do not cease when a railway is made, but are merely transferred laterally and further afield.

It is these credits, and not the estimated receipts from goods and passenger rates which should be used as *criteria* of prosperity; the rates charged have nothing whatever to do with the subject, and are really, *inter alia*, merely a machinery for dividing the expenditure equitably between the actual immediate users and the whole people. So that when the time arrives that the Australian Colonies are so intersected by a net-work of lines so that every inhabitant is equally served, free railways would be financially justifiable, and the working expenses and interest might be charged wholly to the general taxation revenue.

Mr. W. M. Acworth, who is one of the greatest living authorities on railway matters, adverts to the possibility of such an arrangement, when the Government owns the lines, in a valuable paper on "The State in relation to Railways."

We may illustrate this by the parallel instance of the public roads and road bridges. These are made and maintained in Australia by the Government, or other public bodies, but there is no direct revenue therefrom, from the actual users, which of course might be obtained by the establishment of turnpikes; hence if the same method of estimating whether they were paying public works or not were used, as is usually done in the case of the other means of communication—railways, there would be nothing on the credit side, and the whole interest on the outlay and the cost of the maintenance should be put down as a dead loss to the country, which, of course, it is very well known, they are not.

If it be said that the credit due to saving in transport goes chiefly to the locality immediately served, while the debits are paid by the whole community, it may be answered that this is only partly and temporarily the case. The cost of local production exported is cheapened by the saving in transport, while the imports balancing them hold the same value as before; hence the local producers would appear to be, at the first glance, those only who benefit. But in the first place, the locality pays so much of the expenses as is represented by the rates and fares, and secondly, the cheapening gradually affects the whole market, for the enrichment of the locality leads to its extra trade with outside, and it diffuses itself in different directions. Again, even if local advantage were to some extent derived at the general expense, the whole contention of this paper presupposes an ultimate, and as far as practicable, fair distribution of expenditure by the Government on communications, whether by railways, rivers, harbours or roads, throughout the State, according to its needs.

This more enlarged view of the benefit of improved communication is not, of course, new to economists, but it seems to be necessary to bring it more distinctly before the general public

than has hitherto been the case, judging from the way the matter is generally discussed in Parliament, and in the Press. What are called the indirect advantages, which, as regards saving in transport, are always calculable, are not indeed absolutely ignored, but they are merely alluded to as indeterminate general collateral advantages, instead of their being the only ones.

If all these matters were considered, instead of the mere departmental or shareholders' profit and loss view, which is alone regarded in the published figures, and hence in the popular estimate, the complaints, which we hear so often, of the existence of a number of, so called, non-paying branches, would cease, as many of them would, on the contrary, be found to be returning a substantial dividend.

An example is then given, applying these principles to 422 miles of light railways, authorised within the last few years, and partly constructed, in New South Wales and Victoria, and more particularly the 230 miles, comprising five lines, in the former colony, more figures being in this case available. It is shown from official published figures, which are given in detail in the paper, that the working expenses of these five lines, with interest on cost of construction, will be about £200 per mile per annum. Taking the average cost of conveyance of passengers by road at 6d. per mile, and of goods at 10d. per ton per mile, and assuming the quantity of these to be as estimated officially, the gross saving in transport, that is to say the amount hitherto spent in road carriage will amount to £570 per mile per annum, giving a net return, on this method of calculation, *after both* working expenses *and* interest have been paid, of nearly 11 per cent. on the estimated capital. This, moreover, does not include the saving in cost of conveyance of live stock, nor the credits, Nos. 2, 3, and 4, mentioned above, all of which are difficult to estimate, but which must necessarily amount to a large figure.

The official estimate of receipts, by rates and fares, on these five lines, shows, as compared with the working expenses and interest, a small loss ; but these lines were apparently sanctioned, not because these receipts were disregarded altogether, as they should have been, and the proper credits, as shown above, substituted, but because it was thought that by the hastening of the development of the country, through the making of the lines, this imaginary loss would soon be converted into an equally illusory gain. That this popular impression is illusory, and that decisions are frequently better than the reasons given for them, is confirmed by the fact, that nearly half the total railway mileage of New South Wales, at the present time, is working at a nominal loss of £284 per mile per annum, most of it being working for many years without reaching the desired turning point, nor is it likely

to do so ; yet no one seriously proposes to close half the railways on this account.

The conclusion, drawn, therefore, is, that generally, in easy country, the working expenses for a light traffic, with interest on capital, need not exceed about £4 per mile per week, and taking passengers and tons of goods as units, and including traffic in both directions, it would only require the saving in transport of less than 6,000 of these units, annually, to repay expenses and interest. All traffic above that, besides what may be called the direct credits, before enumerated, would be to the good.

This figure, 6,000, is not much more than a third of that officially estimated as supplying, on an average, the traffic on each of the five lines referred to.

Notwithstanding this encouraging way of estimating the value of future railway extension by the colonies, a word of warning is uttered against costly extension into poor districts, and also short branches, which are specially expensive to work ; and the paper concludes by pointing out that the treatment of the subject is limited, in it, to the usual case of railway superseding road carriage. Sea, river, or rival railway competition, give rise to different figures and to the conclusions based upon them, though, of course, the principle is the same.

No. 3.—ON THE RAPID ERECTION OF A STEEL VIADUCT TO REPLACE A TIMBER STRUCTURE ON THE NEW SOUTH WALES RAILWAYS.

By Walter Shellshear, M.I.C.E.

(*Read Saturday*, 8 *January*, 1898.)

[*Abstract.*]

The paper describes the work of renewing Nos. 3 and 4 of the series of timber viaducts across the Murrumbidgee River flats flanking the fine iron bridge over the river.

On the north side of the river, the viaducts consisted of No. 1 (112 spans), No. 2, (65 spans), No. 3, (4 spans), No. 4 (71 spans), and on the south side, No. 5 (57 spans), and No. 6 (5 spans) the span in each case being 29 feet 6 inches, the total length being 9,263 feet of timber work.

The Railway Commissioners decided, in consequence of the condition of the timber structures, to replace them with permanent steel and concrete viaducts, the work to extend over four years, and the first portion of the work having recently been completed, the author explains the method adopted for construction and maintenance of traffic.

The new viaducts are of steel in 29 feet 6 inches spans supported on steel trestles, (every tenth pier being carried up solid in concrete to counteract brake thrust) and were designed by Mr. Firth, Engineer for Existing Lines, the erection being entrusted to the author.

The centre line and level of the new work are the same as the old, and in addition to the maintenance of traffic, the prevention of damage by possible flood had to be provided for.

The foundations were formed of concrete, and were put in at a distance of 10 feet from the old foundations, for the dual purpose of getting into undisturbed ground and not interfering with the existing structure.

Each trestle was supported on two blocks of concrete 6 feet 3 inches x 4 feet below ground, with a moulded circular top above ground 4 feet in diameter. The solid piers were moulded in framing in the usual way, and were supported on rectangular blocks of concrete, varying in size according to the height of piers. The depth of foundations varied from 5 feet to 15 feet, according to the nature of the ground and the liability to scour in flood-time.

To facilitate the handling of material a temporary siding was laid parallel to the viaduct, and about 30 feet from it.

The concrete for the piers was deposited through holes in the deck of the old viaduct, the material being raised in barrows by a whip. Each pier was completed in a day, so that there was no joint, and the holding-down bolts for bed-plates and trestles were built in.

The weather being most favourable, the excavations, with one or two exceptions, required no timbering; and as the concrete went in at once, they were subjected to as little exposure to weather as possible.

The concrete for No. 3 viaduct was commenced on February 19th, 1897, and the whole of the concrete for Nos. 3 and 4 viaducts was completed on June 18th, 1897.

In erecting the superstructure and removing the old timber-work the considerations were—1st, to reduce all temporary work to a minimum; 2nd, to reduce the risk of damage by flood to a minimum; 3rd, to so arrange that sections of old timber-work could be removed and new structure erected between the times of ordinary trains, and to avoid Sunday working as much as possible.

The girders were unloaded from trucks to cradles prepared for them, and each pair then connected with the cross and wind-bracing, and the sleepers fitted and bolted, each span then being ready for its place.

The trestles were unloaded opposite their sites and slid over into place, and carefully levelled and lined up, bedded on the circular foundation blocks, usually four or five days before the girders were fixed, to give plenty of time for setting.

Two travelling cranes were used on the siding for handling these.

When the steel trestles were in place, and the new spans ready for erection, the old superstructure was removed, being first lifted with hydraulic ship-jacks and sliding rails lubricated with soft soap, and $\frac{1}{4}$ inch steel sliding-plates inserted, this being expeditiously done, as it took only a few minutes to lift with the 100 ton ship-jack.

Everything being ready to remove a section as soon as the last train had passed, the rails were removed and run back, the old girders having been sawn through with a diagonal cut, and the overhanging end supported by temporary props; and when the strap-bolts were removed, the jacks were manned, and the old superstructure slid over the ends of the headstocks and down sliding rails where the height was small, or arranged to turn over as it slid from the headstocks where the depth was sufficient, this operation taking from five to ten minutes. Meanwhile the engine attached to the crane had slung and brought over the new span, ready to lower into position; and as soon as the first span was in position and bolted down, the rails were laid on it, and the operation repeated until the gap was filled up.

A tabulated account of each day's work showed that No. 3 viaduct of 4 spans (a total length of 118 feet) was erected on Sunday, July 4th, in about $5\frac{1}{2}$ hours; that 3 spans of No. 4 viaduct (88 feet 6 inches) were erected on July 16th in $2\frac{2}{3}$ hours; that on July 30th, 5 spans (147 feet 6 inches) were erected in 2 hours 13 minutes; on August 13th, 5 spans in 2 hours 22 minutes; on August 20th, 5 spans in 2 hours 21 minutes; on August 27th, 6 spans (177 feet) in 3 hours 5 minutes; on September 4th, 5 spans in 2 hours 8 minutes; on September 10th, 6 spans in 2 hours 37 minutes; on September 17th, 6 spans in 2 hours 35 minutes; on September 24th, 6 spans in 2 hours 37 minutes; on October 8th, 6 spans in 3 hours 8 minutes; on October 22nd, 6 spans in 3 hours; on October 29th, 6 spans in 3 hours; on November 26th, 5 spans in 3 hours; and on November 28th (Sunday), the closing span and fitting.

The whole of the work was carried out without any delay to the traffic, and with no accident other than a few pinched fingers

and a sprained leg. Preservation from liability to flood was studied, and Sunday work was limited to two Sundays only.

The number of men employed never exceeded 1 foreman, 5 carpenters, and 30 labourers.

The weight of each span of the new structure, with sleepers fixed, was about 6½ tons.

The weight of the longest section of the old timber superstructure, with ballast, &c., slid off at one time, was between 120 and 140 tons.

The paper was illustrated by several photographs and diagrams.

No. 4.—NARROW-GAUGE RAILWAYS—THE 2-FEET GAUGE LINES IN TASMANIA.

By Fred Bach, A.I.C.E., F.S.S., &c., General Manager Tasmanian Government Railways.

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

After introductory remarks, the author said:—First, there is nothing novel in the construction of 2-feet gauge lines. As far back as 1832 the Festiniog Railway Company was incorporated, its gauge being 1 ft. 11½ in. In 1869 it was re-incorporated and practically reconstructed at a cost of £10,727 per mile, the ruling gradients being 1 in 80.

The 2 feet gauge lines are in operation in almost every country in Europe, and largely in India.

What is comparatively new in the working of 2-feet gauge lines is the recent increase in the weight of the locomotives.

In Tasmania, the largest locomotive on this gauge weighs 20 tons, and is capable of hauling 50 tons up a grade of 1 in 25 with curves of 1½ chain radius.

I think that in the near future we shall have 40 ton locomotives in use on this 2-feet gauge.

The reasons for departing in this instance from the standard gauge in Tasmania was due to the intention originally of running a light tramway into this mineral part of the country north-east of Zeehan; but the developments in mining and the prospects of

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Note—The paper was illustrated by lime-light views, showing the character of the line and the nature of the country.

traffic increased so rapidly that it was thought prudent to strengthen the proposed light tramway, and make it a strong 2 feet gauge railway.

The country traversed by this line is mountainous and exceedingly broken.

The north-east Dundas line, after 4 miles of comparatively easy country, commences to ascend, and at 10½ miles, after much twisting and turning, reaches an altitude of 1,015 feet above Zeehan.

The steepest grade is 1 in 25, in combination with 1½ chain curves.

The rolling stock in use on this line has been constructed in the colony, excepting the locomotives. The standard locomotive used weighs 19¾ tons, and takes a 50-ton load up a grade of 1 in 25.

The goods trucks carry a net load of 10 tons, the weight of truck being 2 tons 14 cwt.; thus we can negotiate grades of 1 in 25, in combination with 1½ chain curves, with a paying load of 40 tons per train, which, with four daily trains in each direction, would make the carrying capacity of the line 100,000 tons per annum.

Briefly, the specialities of this class of railway are: Gauge, 2 feet; maximum gradient, 1 in 25; minimum radius of curves, 99 feet; width cleared, 30 feet, to be increased where necessary; cuttings 10 feet wide at base, and embankments 10 feet wide at top; bridges all timber (stringybark and blue gum); log culverts and timber boxes; ballast, 800 cubic yards per mile, being 4 inches deep under sleepers; the sleepers 5 ft. x 8 in. x 4 in., stringybark and blue-gum; rails, steel, 46 lb. and 40 lb. to the yard.

The cost of the line, including surveys, construction, and equipment is approximately £2,000 per mile; and in justification of its adoption I may say that we are constructing and equiping nearly 20 miles of it at a cost of about £40,000, whereas our ordinary 3-feet gauge line, through the same country, would probably cost £10,000 per mile, or (say) £200,000.

The interest, at 3½ per cent., on these respective amounts shows a saving in favour of the 2-feet gauge line of £5,600 per annum, which, at compound interest, would, in less than seven years, be more than the total cost of the 2-feet gauge railway.

No. 5.—NOTES ON THE ACTION OF CERTAIN EXPLOSIVES.

By F. Marchant, M.I.C.E. (Timaru, New Zealand).

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

In the use of explosives in subaqueous work, the following notes on the burning of blasting gelatine and the sympathetic explosion of dynamite may be of interest to engineers :—

1. *For the purpose of loosening a harbour bottom before sinking some large mooring screws, a 3-inch pipe was lowered as a drill guide from a staging that had been erected, and was sunk through a 3-foot loose gravel upper stratum to a hard sand surface, into which a $2\frac{1}{2}$-inch hole was bored to a depth of* 20 *feet.*

When it came to loading the blasting charge holders, which were two galvanized-iron tubes, each 7 feet long and 2 inches in diameter, there was not sufficient dynamite, and the deficiency was made up with blasting gelatine, the proportions being about five-eighths dynamite and three-eighths gelatine.

Although there was full knowledge of the high initial detonation required to explode the gelatine, it was naturally thought that when the dynamite exploded the gelatine intermixed with it would also explode.

The result, on firing by an electric battery from the staging the charges in the tubes, which filled 14 feet of the bore-hole, was an uprush from the guide-pipe of a roaring blast of violet-coloured smoke shooting up 20 feet into the still air and forming a mushroom shaped cloud which quickly fell on the staging, which the men had already, without mishap, quitted by a boat.

In previously sinking six screw moorings in the same harbour with precisely similar operations, but with dynamite alone as the explosive, no such smoke occurred.

The conclusion therefore deduced is, that the dynamite in exploding does not give a sufficiently quick series of vibrations to effect the detonation of the gelatine, and that the latter simply burnt furiously without having any explosive effect.

2. *On the Sympathetic Explosion of Dynamite.*

In breaking up portions of a wreck in about 21 feet of water, charges of dynamite, each about 7 lb., in galvanized-iron canisters, were attached by a diver, and a line attached, its upper end being fastened to a float.

The usual firing battery having been damaged, the charges were exploded by sympathy, as follows, viz. :—A heavily-weighted canister, containing 3 lb. of dynamite, with two lengths of waterproof fuse, each about 3 feet long, was employed, the fuses lit in a boat, and the charge run down the guide-line among those previously set by the diver. All charges exploded simultaneously, with no misfire.

This sympathetic action of higher explosives, though well known and often taken advantage of in military torpedo practice, would seem to be less widely known and made use of by civil engineers than it ought to be.

In the case in question no charge was more than 6 feet distant from the next, but much longer ranges would be effective.

No. 6.—SOME REMARKS ON DETAILS OF HOSPITAL CONSTRUCTION AND LAY MANAGEMENT.

By C. E. Owen Smyth, Superintendent of Public Buildings, Adelaide.

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

The author, after a reference to a paper on "Hospital Construction" read by him at the Adelaide meeting in 1893, and to his being the Officer-in-charge of Hospital Construction in South Australia, dealt first with the questions of drainage and sewerage.

He emphasised the necessity for the absolute separation by trapping and ventilation from the main sewer, and in larger hospitals of the separation of each section of the drainage system from its neighbour.

Failing a good water pressure, however, he would never allow in a modern hospital a drain-pipe to be used, but treat everything on the surface, and apply daily cleansing.

He stated that there was a vast difference between sewer *gas* and sewer *air*—a fact not generally recognised.

Treating next upon the use of disinfectants, he referred to the frequent want of knowledge as to their proper application, and the necessity for intelligent direction in this matter to young nurses and hospital attendants.

He spoke upon pedestal closet pans, baths, lavatories and sinks, which in addition to having every part as far as possible visible to the eye, and unencumbered by casings, should receive much greater attention in regard to cleansing than he feared was generally paid to them.

For provision against accumulations of dust, he recommended that any presses should have sloping tops of galvanized iron clearly visible; that mouldings and projections should be as few as possible; and that the meeting rails of windows and the tops of doors and screens, &c., should receive special attention.

He considered steam power an essential now-a-days in every hospital, not only for cooking and hot-water supply, but also to save laundry labour and to provide immediate means of disinfection.

Upon the subject of the most suitable disinfecting apparatus, he alluded to the claims of the Washington Lyon Super-heated Steam Disinfector; to the Equifex Steam Disinfector (Geneste-Herscher patent), made by Defries and Sons, of London; and to Dr. Treschs' machine—and would be glad of opinions from those who have had experience of any of the above. The consensus of English M.O.H.'s opinions seemed at present to be in favour of the Equifex.

Since reading his paper at the 1893 meeting, he had arrived at an improvement in the heating of operating tables, by introducing heat in the centre of the table under the loins and back of the patient.

The subject of operating theatres was too large for this paper, but he would recommend a paper by Dr. Smyly, of Dublin, in the British Medical Journal, of July 10th, 1897. Hospital construction must, under this head, keep pace with the surgeons, who were moving very rapidly.

With a view to rendering wards as far as possible fly-proof, doors, windows, fireplaces, and other vents should be provided with brass or galvanized wire fly-proof mesh screens, the cost of which would be well repaid by the result, and these should be kept scrupulously clean and brushed over with turpentine periodically. All *post-mortem* houses especially should be fly-proof.

The subject of isolation hospitals was one that should not longer be delayed in Australasia, and he considered that officers responsible for hospital construction in the various colonies should make a point of pressing this subject upon the various Governments.

For small, detached isolation wards, where economy had to be studied, galvanized-iron, sun-proofed on both sides with a lime-wash mixed with boiling water and fastened with sugar, salt, and raw linseed oil, would be found an excellent sheathing, and by lining the interior and ceilings with small fluted 28-gauge iron, coated similarly on the outer side and painted with zinc on inside and varnished, one would have a very cheap, serviceable, and sanitary structure. Fly-proof screens to openings would be an essential, and also broad verandahs.

No. 7.—ARCHITECTURE AND THE ALLIED ARTS IN NEW SOUTH WALES.

By J. B. Barlow, President of the Institute of Architects of New South Wales.

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

It has been said that the more abstract and ideal an art is, the more it reveals to us the temper of its age. "If we wish to understand a nation by means of its art, let us look at its architecture or its music." This is true as far as architecture is concerned, though it would seem that as a living art it flourishes only among a young and vigorous people ; and that painting, sculpture, and music, at their highest, are the arts of a nation's decadence.

We have the evidence of history, in every country, that architecture has invariably began to decline before men turn their attention to literature and the fine arts. England may be taken as one example of this. Within the two hundred years immediately succeeding the Conquest, twenty-three cathedrals, besides numberless great abbeys, keeps, and convents were erected. During this golden period of English architecture nothing at all was done in the sister arts of painting, sculpture, and music ; nor was there any literature worthy of the name : but in the middle of the 14th century, when architecture begins to lose its force, we find that the art of illumination is cultivated, and Chaucer's pilgrims ride to Canterbury. And as literature grew, and waxed strong, the "seven lamps" which had burned so brilliantly during the dark ages, grew gradually dimmer as the years went by. The lamp of beauty brightened once again, certainly, in the Chapel of Henry VII, but it was only with the momentary brightness of an expiring flame, for immediately afterwards it went out utterly. English architecture was then delivered into the hands of Italian and German Philistines, who built palatial houses for the nobility, where, in most instances, there was a lavish display of wealth, combined with a plentiful lack of taste. Then came Inigo Jones and Wren, with their adaptations of the style of the Italian revival ; but even their genius was powerless to make those dead bones live. The impetus of their influence soon died away, and in the 18th century, the Augustan age of English

literature and of English painting, architecture had ceased to be an art, and had become archæological.

What I wish to show is, that all art moves in cycles; that the architectural cycle is first, and sculpture and music are the last in the scale; that these cycles have occurred in precisely the same order in the life of every nation, and it is reasonable, therefore, to assume that they will occur in the same way here; and, further, that it is only during the continuance of its own particular cycle that any of the arts can be said to be really vital, and capable of its loftiest expression. Let me cite the latest instance in support of this argument. It can scarcely be said that the United States has a national literature; and, though there are many clever American painters and sculptors, it certainly has no national school of painting or sculpture. But that a national architecture is gradually but surely being evolved there, must be evident to everyone who has given the matter a moment's attention. Does not the phrase "an American house" convey a distinct and very definite idea to the mind of every architect?

The United States is now in its architectural age; and if there is anything in my contention with regard to the periodicity of art, then we in Australia will shortly be entering upon a similar cycle. A distinct national character in architecture is a natural growth. We cannot create or control it, but it will be gradually evolved. It will be probably nothing very novel, but whatever it is, it will reflect the temper of the age as no other art can. We cannot hasten its coming, but we can at least do something in making straight the way. If my theory be a correct one—if history in this instance is to repeat itself—then the birthplace of the new architecture must be looked for in Africa or Australia. America may yet do much, but we must not forget that architecture progresses rapidly to maturity; and that after a comparatively brief period of full-blooded existence it becomes corrupt, and sinks into an apparently premature decay. And the American cycle, as we have seen, precedes ours; so that we will profit by their experience, as we profit by the experience of every other nation. We are the legatees of time in this respect, and, if we make the best use of our opportunities, the world may, in its old age, look to Australia for the ultimate expression of whatever is great and noble in architecture.

Art in Australia still awaits its evangelist, but, in the meanwhile let us do what we can to set our house in order, so that when he comes he may feel that at least he is not an unexpected guest.*

* We might, for instance, strive to prevent the purchase of any more alleged bargains in the shape of statuary. We have already more than our share of bronze and marble imbecilities in our public parks and gardens; and it would be a distinct gain to Australian art generally if all of them, with perhaps two or three exceptions, were consigned to the lime-kiln or the melting-pot.

Sydney, by reason of its site, and the accident of its irregular and careless growth, is even now the most picturesque of Australian cities, and its narrow crooked streets are full of pleasing possibilities in the way of unexpected architectural effects. The grouping of the dome and cupolas of the new markets, when looked at from George-street, north of the Post Office, is a recent and pleasing instance of this. It does not need the gift of prophecy to foresee that during the next century Sydney will be practically re-built; but sufficient has already been done, however, to prevent much alteration with regard to the width and the shape of the principal streets. But in order that the work of those who come after us may not be impeded, we require some safeguard against departmental blundering. This end, I think, would be achieved by the appointment of a permanent board of experts, whose duty it would be to confer with and advise the Government on all matters connected with the improvement of the city.

The formation of a Board, such as is here suggested, is not a new idea; for nearly three centuries Paris has had her Council-General of Public Buildings; and it is not too much to assert that the Paris of to-day is incomparably the finest city in the world. This result is due, mainly, to the work of the Council-General.

Such a Council would undertake in part the duties now performed by the Public Works Committee, the City Building Surveyor, and the work formerly done by the City of Sydney Improvement Board; but above and beyond all this it would protect the public interests from an æsthetic standpoint. Such a Board would have prevented much unnecessary expenditure in Martin-place. It would build up, but it would also pull down. For instance, I do not think it would tolerate the existence of the inhumorous grotesques which fill the Post Office spandrels, or of those other graven images which fail to fill the niches of the Lands Office. This Board would also include in its functions the management of the Art Gallery Trust.

It may be asked why is it necessary to take all this trouble on behalf of a public which cares nothing about these things—a public which looks with complacency on the stained glass of the Town Hall staircases, and which possibly mistakes the Centennial Park statues for works of art! It is because of this, and in order that they may be prepared for the artistic destiny which undoubtedly awaits them, that this paper has been written and these suggestions made.

No. 8.—THE ORNAMENTAL TREATMENT OF IRON AND STEEL IN BUILDING WORK.

By James Nangle.

(*Read Monday*, 10 *January*, 1898.)

[*Abstract.*]

(Reference to the remarkable development during the present century in connection with the use of iron and steel in ordinary building construction.)

Their use in building works of a purely architectural character can, however, only be regarded as successful as far as construction is concerned, their treatment æsthetically being disapproved by lovers of truthfulness in art.

The large metal structures of the engineer have been more successful, these being at least honestly expressive of the materials in most instances, and therefore truthful, and often possessing an inherent beauty of their own.

(Reference to the Brooklyn Suspension Bridge, also to the Forth Bridge, and to a still more recent progressive example of a bridge on the cantilever principle proposed to be erected over the Hudson, as examples of truthful construction ; and reference to the recent Tower Bridge over the Thames as an example of untruthful construction, the steel towers in this case having been clothed with an external veneer of masonry designed by an architect, the masonry being hung to the steel skeleton, and the effect being dissatisfying, as the towers, while appearing to be stone, are subjected to stresses which they could not endure if they really were what they appear.)

The tall steel buildings of the United States covered with veneers of stone or terra cotta with details of historic styles distorted in proportions, are similarly architectural frauds of the worst kind ; but they are, after all, only the consistent result on a large scale of what is practised on a small scale in modern architectural work.

That a style peculiar to metallic construction and yet both truthful and beautiful, has not been rapidly evolved, is not a matter for surprise, when it is remembered how slow was the development through the trabeated styles of the Greeks,—derived from the post and lintel timber structures of early times,—to the true or genuine use of stone under compression rather than transverse strain, as in the arched and buttressed architecture of the middle ages.

As it took all those centuries to arrive at the most logical use of stone, it can hardly be expected that an immediate solution be reached for the successful treatment, æsthetically, of materials which, if truthfully used, would upset all the traditional and much reverenced laws of proportion and beauty of detail.

Mr. Ruskin, in treating upon the question, says "that if iron and steel are to be used largely in building work, it means that new laws of proportion and detail must be invented to meet the case."

It may be predicted that a true metal treatment in architecture will be characterised by lightness and expression of sinewy strength, in place of the mass and repose of the styles of the past.

The unsatisfactoriness of the present methods of treatment results from the concealment of the construction, producing an effect of lightness without strength.

While for many reasons, including risk from fire, some covering of the essential construction is unavoidable, this does not necessitate that such covering should be a fraudulent imitation of other material.

(Reference to cases where metallic construction may be exposed and treated ornamentally in accordance with their character, and reference to iron roofs.)

In the subordinate use of iron and steel construction in subsidiary portions of a building, such as staircases, lift framing, shutter frames, &c., where covering is non-essential, the problem is simpler, and there are already illustrations of its solution, as in the Equitable Insurance Building in Sydney, where artistic treatment is combined with truthfulness.

In conclusion, it is safe to predict that iron and steel will be used more and more in the future, and architects must face the question of a treatment that shall be truthful and artistic as well as constructional.

No. 9.—NOTES ON THE RECENT FIRE AT MELBOURNE.

By John Sulman, F.R.I.B.A.

(*Read Tuesday*, 11 *January*, 1898.)

Passing through Melbourne a few days after the occurrence of the recent fire, I took the opportunity of carefully examining the ruins and gaining further information by seeing some of those interested in the properties. Soon afterwards my partner, Mr. Power, was in Melbourne, and he also made a careful inspection and in addition interviewed Mr. Stein the Chief Officer of the

Metropolitan Fire Brigade. At the first meeting of this Association in this building, just ten years since, I had the pleasure of reading a paper on "The Fireproofing of City Buildings," and it therefore occurred to me that a few further notes on the same subject, especially in the view of the lessons taught by the Melbourne fire, might be of interest at the present time. The block which has been almost entirely destroyed measures approximately 660 feet from E. to W., and 313 from N. to S., and is bounded by Elizabeth-street on the west, by Flinders-street on the south, by Swanston-street on the east (all three 99 feet in width), and by Flinders-lane, 33 feet in width on the north.

It was occupied mostly by warehouses, some of them seven and eight storeys in height, and intersected by a few narrow lanes and rights-of-way, making altogether what the Insurance Offices would call a hazardous risk.

With the exception of the Mutual Store, all the buildings were of the ordinary construction—*i.e.*, brick walls, timber floors, in many cases ceiled with match-boarding, wooden roofs covered with corrugated iron, and hence very inflammable. Some had iron shutters to their windows, fire-mains, and other precautions, but these proved useless in consequence of the faulty construction of the buildings from a fire-resisting point of view.

The progress of the fire may be best gathered from the report of Mr. Stein, and summarised is as follows:—It commenced in the seven-storey warehouse of Messrs. Craig, Williamson, and Thomas, facing Elizabeth-street, which, when the firemen arrived, was fully alight, flames coming out of the windows up to the fourth floor, and hence impossible to save. A heavy westerly wind was blowing, and the firemen's attention was mainly directed to saving the adjoining buildings but without avail. In ten minutes time the upper part of Fink's eight-storey building was alight. The doors were burst open and a rush made by the firemen to use the fire-hose with which the building was fitted, but the roof fell in and drove the firemen out. At this moment news came that the wooden structures on the flat asphalte roof of the Mutual Store were ablaze, but thanks to the character of the roof this was got under; meanwhile the fire, under pressure of the heavy wind, had got through to Flinders-lane. A few seconds after this, Mr. Stein noticed that Crawford, King, & Co.'s, warehouse was burning, and very shortly after that Sargood, Butler, Ewen, and Nichol's large softgoods warehouse adjoining had caught on the roof. In a quarter of an hour it was gutted. During this time the fire had attacked the Mutual Store at various points, but the firemen were able to keep it under. Going round to Flinders-lane, Mr. Stein found that the fire had got through in Sargood's rear warehouse, but that the warehouses on each side were as yet untouched. The flames had also penetrated to the lane through

the vacant warehouse behind Craig, Williamson, and Thomas's. The two warehouses to the east of Sargood's in Flinders-lane were the next to go, but by constant hard work Monahan's eight-storey building, at the corner of Swanston-street and Flinders-lane was saved, as were the whole of the other premises facing Swanston-street. Up till now the six-storey building behind the Mutual Store and Stevenson and Son's four-storey warehouse had been preserved; but the lanes and rights-of-way having become blocked by falling walls, the firemen could no longer get to the rear, and they, too, fell a prey. By this time the fire was under control and was gradually conquered, but not until it had made a clean sweep of the whole block except the Gresham Buildings, the Mutual store, and the buildings facing Swanston-street. The first-named was saved largely owing to the wind driving the fire eastwards, while the latter were saved by the exertions of the fire brigade—by that time in great force. The Mutual Store was known to be specially constructed to resist fire and was also almost isolated from adjoining buildings, thus giving the firemen confidence, and justifying the paramount efforts made to save it. With its construction I will deal later on.

The scene of the fire itself, when I saw it, presented several items worthy of consideration. The most striking was the great destruction of apparently substantial brick walls. For instance, between Crawford's and Sargood's there were two external walls built against one another, and aggregating fully 4 feet in thickness. These were down almost to the ground level. Was this owing to the heat of the fire buckling the brickwork? I think not; because other walls, as at Fink's, where the fire was equally fierce, are standing. My solution is this: The walls are of great length and unsupported by cross walls, hence weak to resist side thrust or pull. The girders in Sargood's were of iron and I believe continuous, and the ends were also probably built tight or fixed in the walls. The first action of the heat would be to expand the metal and force the walls out; then, as the heat increased, and the metal began to soften and sag, the girders pulled the walls down. This theory is confirmed by the hollow space of 4 or 5 inches now existing between the remains of the two walls referred to, for a greater part of the length, but not near the front and rear, where they have the support of the front and rear walls. Further, a large part of the east wall of Sargood's fell over into Lincoln, Stuart, and Co.'s premises, thus evidencing the pushing power of the girders, possibly aided by the greater expansion of the bricks of the interior of the wall over those of the exterior.

It may be objected that clay in burning shrinks, but this is only when it is damp. When burnt, I believe it swells with further heat. In support of this I would point to the immense crack running almost from top to bottom of the east wall in

Fink's Buildings. At the bottom the walls are thick, gradually reducing upwards, so that the upper portions would be more quickly heated through, and in expanding would force out the return walls at each end. On cooling, the brickwork not having sufficient cohesive power to pull the walls back again, must crack, and did so, the crack being widest at the top and dying off to nothing at the bottom. An eye-witness states that the crack increased in size as the building cooled. Fink's Buildings, though excessively tall, is a testimony to the value of return walls at reasonable distances apart. Comparing this with Crawford's and Sargood's, allowance must, however, be made for the fact that Fink's Buildings was mainly occupied as offices, whereas the two latter were warehouses, stacked with inflammable goods, and hence the intensity of the fire was much greater. A marked example of the bulging of a wall may also be seen in Mr. Wise's premises, where that adjoining Fink's Buildings is bent like a bow, but had not fallen.

The extraordinary shapes that wrought-iron takes when subject to heat is exemplified in many of the destroyed buildings, but it is too well known to need description. I must, however, call attention to the defective system of construction adopted in many of the buildings, in connecting columns and girders. Instead of the cast-iron columns seating on one another from top to bottom of the buildings, and allowing the girders to pass through boxes, or be supported on brackets, the girders are simply stiffened at the bearing point and the columns seated thereon storey by storey. It is bad for ordinary weight-bearing, but worse when attacked by fire; for the girders, being continuous, have much greater thrusting and pulling power on the walls, and directly one girder goes a heavy additional strain is put on all above it. By seating column on column this would be largely avoided; and had it been adopted much of the great destruction of the walling and spread of the fire would, I believe, have been obviated. A remarkable escape of a whole front (that of Crawford and Company's) with extremely slender cast-iron columns must also be referred to; while in an adjoining building the cast-iron of some of the columns is partially melted, showing the intensity of the heat. In the former case the wind, however, blew the fire away from, while in the latter it blew it on to, the columns. It is well known that firemen are very distrustful of ironwork in buildings, and with reason, and also that they advocate wooden girders and posts in lieu thereof. In the small stores adjoining Fink's Buildings to the east, timber was used for this purpose. The charred remains of the girders are still in position, but were so badly burnt as to be useless. In Crawford & Co's. three-storey building the timber girders have, however, suffered even more, being totally destroyed, and only a black line of charred material shows on the debris

where the girders fell and were consumed. In both cases the timber used was Oregon; but the same result ensued in Messrs. Edgerton and Moore's premises in the lane, where hardwood had been employed. It is usually contended that, when charred to a depth of an inch or so, timber girders will then stand fire for a considerable time. They have not done so in this fire; and in addition the walls (in one case, viz., Crawford's) have suffered just as badly as in the adjoining building where the girders were of iron.

From the roof of the Mutual Store, whence the best general view of the ruins was obtainable, the rows of iron shutters guarding the rear of Stevenson and Son's warehouse were a noticeable feature. Several were bulged and twisted, but many were intact. This, however, was not the case inside the buildings, where they had failed—not so much the doors themselves, as the tracks and runners, which could not withstand the fierce heat and thus let the doors down.

It is now time to consider the Mutual Store, the only building in the midst of the fire which survived it, to ascertain, if possible, how much this was due to special construction, and how much to favouring circumstances. The latter were marked. For instance, on the west it abuts mainly on an open yard space, low two, storey buildings occupying the frontage, and on this side the store has but few windows. On the north is a right-of-way, on the east Degraves-street, and the front faces Flinders-street. It was early occupied by the fireman, who hoped to make use of it as a break to stop the fire, and so were able to immediately repel every attack. Its chief feature is a flat uninflammable asphalte roof, and to this, next to the fireman's efforts, I attribute its safety under the special circumstances of the case, viz., high adjoining buildings and a heavy wind. It is on record that burning ashes and flaming debris fell on it in showers, but failed to set it on fire, and it also afforded the firemen an excellent coign of vantage for fighting the flames. Its weak feature is the building on the roof of inflammable material.

The next point to consider is its internal planning and construction. It is divided into two blocks, front and rear, separated by thick walls and with the staircase and lifts between. The openings in the walls are protected by iron doors. The staircase has a brick wall between the flights instead of an open newel, thus preventing up-draught, and the steps are solid blocks of hardwood. The lifts are at one end of this section, and form a flue from top to bottom. If the outer wall of the lift shaft had been omitted the arrangement would, however, have been perfect. The floors throughout the front and rear blocks are of iron girders and terra cotta lumber, the best fire-resisting system at present known; and this no doubt materially aided the firemen by giving

them time to subdue the successive inroads made by the fire in one part or other of the building. Much emphasis has also been laid on the protection afforded by the wire gauze covering the windows, because on the north side, facing Brooks and McGlashan's warehouse, and only separated by a narrow right-of-way, many of the window-frames remain intact; but at the northern end of the east side, facing Crawford's, with a street of double the width between, the gauze coverings failed completely and a couple of rooms were burnt out. The explanation is that on the north side the wind drove the flames away and thus did not test the gauze severely, while on the east, Crawford's being a lower building, an eddy was formed which drove the flames on to the windows. It is therefore clear the gauze is a failure, and I would much prefer iron shutters, when the precaution is taken to have the runners securely fixed. Grinnell's Sprinklers are fitted throughout the building, but they only came into play in a few places.

The Mutual Store is claimed in Melbourne to be the first building of its kind in Australia; but I think it only right to put on record that the Head Office building of the Mutual Life Association of Australasia, in Sydney, which I designed, is constructed on the same lines, and was completed before the Melbourne example was commenced.

Every great fire, if its conditions and spread are carefully observed and analysed, teaches some new lessons and confirms and enforces old ones. I will now endeavour to state these as they have occurred to me. The first and most important is the absolute necessity of the earliest possible information of an outbreak being conveyed to the fire stations, so that a fire may be checked at its commencement. In the present case the first call was received at 2·20 a.m. on Sunday, and a few minutes after, when the men arrived, flames were breaking out of the windows of the four lower storeys of Craig, Williamson, and Thomas's warehouse, thus showing the place must have been burning a long time—in Mr. Stein's opinion since 1 p.m. on Saturday, when the employees left. The possibility of such a thing happening in one of the busiest blocks of a great city without discovery is a grave impeachment of present methods. The solution of the problem is, however, more a question of administration than of building construction, and as such the Fire Brigades Board, the Insurance Offices, and the owners of premises, are the most competent to deal with it. The question seems to resolve itself into the respective advantages or disadvantages of human or mechanical methods. If decided in favour of the latter, architects, and engineers may have something to say, but otherwise had better leave the matter to those specially concerned.

The next lesson is one that other cities have learnt, but which, till lately, we have ignored: I mean the rigid limitation of the

size of an undivided building in hazardous or valuable city blocks. For London the limit has been fixed at 216,000 cubic feet, equivalent to a cube of 60 feet, and this seems to be quite as large as safety permits. Of course, it means inconvenience and extra expense to those businesses which require larger accommodation; but they would, in my opinion, be well incurred to minimise the risk of such calamities. Limitation in height is also as essential as limitation of cubical contents, and on this point fire authorities seem to be agreed that 60 feet is the utmost that, with a good supply of water, can be effectively grappled with. In the centre of our larger cities, where land is so valuable, and concentration of trade is essential, this height would, however, seriously curtail business enterprise. I would therefore suggest that an extension to 90 feet should be permitted, provided the construction is of a fire-resisting character, and that the roof especially be incombustible. In such buildings, rising above the height to which hose-jets can reach, it would also be desirable for each to have its own special water-tanks on the roof, containing at least 1 gallon to every 50 cubic feet of building, and its own fire-main and fire-hose to every floor. Fink's Buildings possessed the tanks and the hose, but they could not be used as the roof and upper storeys, being combustible, caught too rapidly, and thus became a distributing centre that, with Craig Williamson's, set fire to the rest of the block.

The next point is one that is constantly being urged by fire-brigade officials, viz., the necessity of fire-breaks in all large, congested, or valuable blocks. The best form is a strong wall, solid from bottom to top, and with a flat incombustible roof behind it. This is difficult to obtain, owing to the pressing demand for light within the buildings, and to the erratic subdivision of property. It would only be generally feasible if the sites were in one ownership, private or municipal, and leased on specific terms. To continue the subject further would, however, lead us into an abstract discussion of political or social economics, and would be foreign to the objects of this paper.

Another form of fire-break is a sufficiently wide lane, or open space; and if a block does not possess such, it should be within the power of municipalities to enforce its construction, the cost thereof being borne by the municipality, as representing the general public, and the owners of the sites comprising the blocks.

The disastrous fire under notice teaches its newest lesson in connection with roofs, showing up the danger of those of ordinary construction, and the comparative safety of a flat incombustible one. There is no question the fire spread principally through the roofs and upper storeys catching first, and that the Mutual Store owed its preservation in a large measure to its flat asphalte roof. Contrary to a general impression, asphalte is incombustible as laid

for paving, and as it will expand with heat and contract with cold without cracking, is very suitable for a position in which it is subjected to great variations of temperature. But even the best varieties, viz., those quarried as a mineral in the Vosges and Jura Mountains of France, soften so much with great heat as to easily dent with heavy pressure, while the inferior kinds would be quite unreliable in such a position. Cement is free from this objection, but cracks instead of expanding and contracting with heat and cold, and so would let wet in. Tiles are much used in Southern Europe for the same purpose, but the vaulting thereunder is thick, and they are constantly being kept pointed to prevent leakage. In India chunam roofs are common and watertight; but the great amount of labour required in their construction would, I fear, render them too costly in these colonies. An absolutely unbroken roof is, of course, the best; but any means of access thereto should be of incombustible material, and skylights, if absolutely essential, should be protected by strong wire guards, kept far enough away from the wood and glass to prevent ignition or breakage. If, however, an ordinary sloping wooden roof is for any reason essential, then the regulation compulsory in Sweden for even two-storey buildings should be enforced, viz., a fireproof ceiling under it. I referred to this more fully in my paper on "The Fire-proofing of City Buildings."

Of equal importance with roofs are the walls and their construction, and the chief lesson the Melbourne fire teaches us is the danger of long high walls unsupported by cross walls. The Sydney Building Act wisely provides that unsupported walls more than a certain length shall be greater in thickness than where cross walls occur. But in a great fire this is not enough, and I think it would be a wise thing to provide that instead of thickening the walls the brickwork so used should be employed in the form of cross walls or buttresses at specified intervals. No more space would be occupied, but the increase in strength would be great. If the limit of 216,000 cubic feet were adhered to, many businesses would require several warehouses to be used in connection, and hence openings in the walls would be necessary. These should not exceed (say) 6 feet in width and be protected by fire-resisting doors on *each* side of the wall, thus leaving an air-space between. Much attention and discussion has been devoted to the best kind of door—some advocating iron, others one of solid wood planks covered with sheet-iron, or even faced with tile or terra cotta slabs or asbestos fibre. But the lesson the Melbourne fire teaches us is, that the hangings and bearings of the door are the weak spots, as if they give the door falls and protection is gone; hence the necessity of two doors to each opening, one on each side of the wall, or else the casing or effective protection of the hangings and bearings. Such doors being heavy are most safely hung on rollers,

and the bars and tracks are especially liable to destruction by fire, even when supported by solid brickwork, as they always should be.

The protection of windows is of vital importance, especially in narrow lanes, and should be made compulsory where they are less than 33 ft. in width. The experience of the Mutual Store shows conclusively that wire gauze is ineffective, and, so far, I know of nothing better than iron shutters.

Turning now to the question of floors and columns, we come to a subject which has received more attention than any other in connection with fire-proofing, as it is apparent that if a fire can be only localised, even for a short time until aid is obtained, most of the serious fires would be nipped in the bud. As, however, I dealt very fully with this part of the subject in my previous paper, I will not now go into the matter again. I may, however, remark that ten years ago the system I advocated as the best, viz., the use of hollow terra cotta blocks in conjunction with iron girders, at that time quite unused in Australia, has since been much adopted in good buildings, and, amongst others, in the Mutual Store. There is no doubt that, owing to this system the firemen were able to check each outbreak as it occurred and so helped to save the building. I cannot, however, leave this portion of the subject without referring to the very general but erroneous impression that zinc is non-inflammable, and hence good material for ceilings, a mistake into which a recent insurance authority fell in writing an article on fire prevention in the Sydney *Daily Telegraph.* As a matter of fact, zinc melts at 736°, ignites at a slightly higher temperature, and in most large fires this point is reached at quite an early stage of the conflagration. From every point of view plaster is more fire resisting, and even thin sheet iron is much better than zinc. The recently introduced asbetic plaster promises well, and it is claimed to be fire proof.

But no precaution with floors and columns prevails much if staircases are open and unprotected, and lift-shafts are cut through the floors from bottom to top. Where the site has a side frontage the plan of subdivision adopted in the M.L.A., Sydney, and Mutual Store in Melbourne is the best; but the majority of sites have access and light only at front and rear. It is, however, quite possible to plan the staircase and lifts so that they shall not add to the danger of a fire spreading, but afford a safe means of exit to employees and access to the whole building to the fireman on whatever floor the fire may have started. The sketch plans show two arrangements. The one marked "A" assumes the need of a passenger as well as a goods lift; and "B" that of a goods lift only. With iron doors to the staircase and goods lift, and a fire resisting floor and ceiling, a fire might smoulder for a considerable time before it would break through the windows or work through to the floors above or below. Plan "B" is more economical and even safer,

consisting as it does of an external iron balcony to every floor and external iron stairs. It is based on what I saw in Chicago a few years ago and would be especially applicable to warehouses containing the more dangerous kinds of goods. In the latter case the important point is to avoid putting the lift in an enclosed shaft.

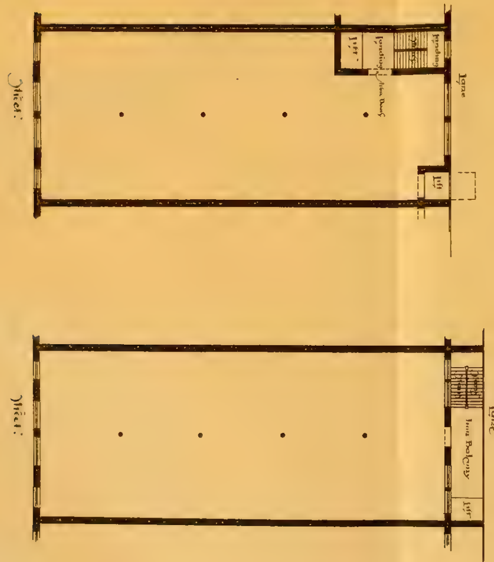
It may be urged that if the foregoing proposals were generally carried out, the cost of building would be unduly increased; but I have no intention of suggesting that they should be made universal. I do think, however, that it would be for the individual as well as the general good, if each city was divided into districts, and some such rules applied to the most valuable, the most congested, and from a fire point of view the most dangerous. For others near the centre, but not quite so important, less stringent rules would serve, while in outlying suburbs each man might well be allowed to do what seems good in his own eyes, provided he was sufficiently separated from his neighbours and thus would not cause them serious risk.

In concluding this paper, may I be pardoned for quoting an extract from the one I read ten years ago in this place, descriptive of the buildings of that period. It is as follows :—

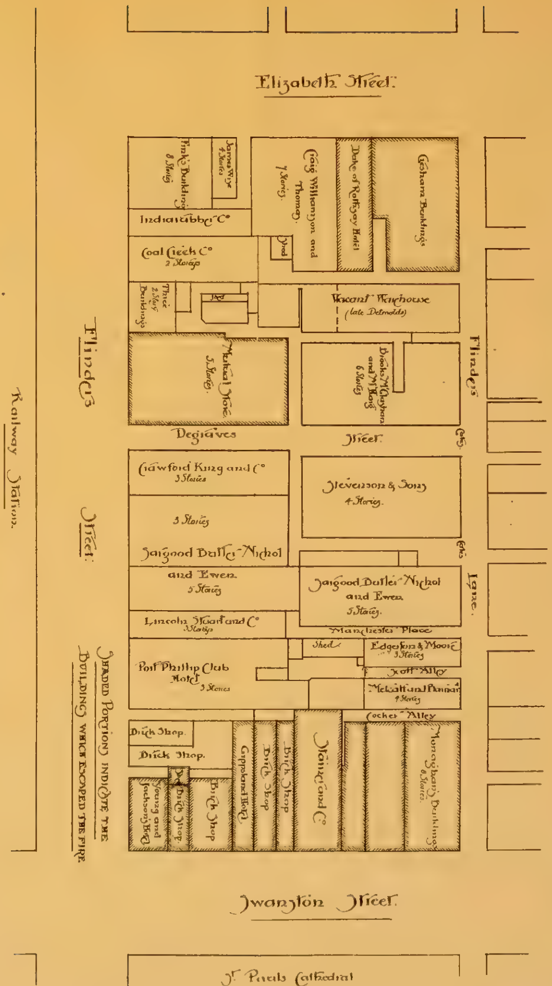
> Our present mode of building is to run up brick or stone walls as thin as the Building Act will permit, fill the openings with wooden frames, form the floors of inflammable Oregon joists, cover them with boards, ceil with thin wooden linings, cut them through from top to bottom for lifts cased in with wood if cased at all, divide the rooms with wooden partitions, erect a wooden staircase, and finally cover all in with a woodon roof: what is this but a magnified match box? Should a fire get a start at the bottom of a lofty building so constructed, nothing could save the occupants of the upper storeys, the danger of spreading would be increased ten-fold, and the risk of a general conflagration greatly augmented.

Since that paragraph was written two great fires have occurred—the one in Sydney, and the other in Melbourne—and both owing to the buildings being of the character described. My criticisms have been more than justified, for several of the Melbourne buildings caught fire at the top instead of at the bottom, and yet their destruction was just as complete. Some progress has been made for which we should all be thankful; but this dangerous class of building is still being erected in the heart of our cities, and my aim is to show that, from every point of view--municipal, general, and individual—buildings of this class should be subject to regulation, and that it would pay everyone better to adopt those improvements in construction which experience has proved to be effective.

DIAGRAMS ILLUSTRATING PAPER by JOHN SULMAN F.R.I.B.A.



SUGGESTED PLAN OF WAREHOUSES TO MINIMISE FIRE RISKS.



SITE OF THE GREAT FIRE OF MELBOURNE Nov 1897.

Notes on the Recent Fire at Melbourne.

By JOHN SULMAN, F.R.I.B.A.

No. 10.—A REVIEW OF SOME OF THE CONDITIONS OF BUILDING CONSTRUCTION AND REQUIREMENTS OF SYDNEY—PAST AND PRESENT.

By G. Allen Mansfield.

(*Read Tuesday*, 11 *January*, 1898.)

[*Abstract*].

To one who has watched the growth of building enterprise in Sydney from comparatively early days to the present time, it is interesting to note the gradual development, both of the constructive art, and of the demands made upon upon it by the manners and customs of the people of the period.

It may fairly be questioned whether this subject is strictly appropriate to a scientific gathering, such as we have here to-day; but it has been thought by some whose opinions are entitled to respect, that a record of such growth and development during a period of nearly half a century of Australian progress would not be without a certain value.

Those who are now beginning the study and practice of the building art, can hardly realise the difficulties that beset the pioneers of Architecture at the date of the half century.

The student who at that day set himself to work to study the theory and practice of Architecture laboured under many and great disadvantages.

The education of the eye plays a most important part wherever in a course of training "Art" is a prominent feature of the study. A proper appreciation of its principles, and a familiarity with its application to practical work, can best be gained by observation and study of executed work. No amount of theory, or reading of books, can supply the knowledge which comes from an intelligent study of good examples. Opportunities for such study were, in the early days, conspicuous by their absence. The number of properly trained and educated architects was very limited, and their works were of no great importance; so that the student had for the most part to fall back upon the information supplied by books and illustrations, supplemented by such teaching as his master thought fit to give him—generally not over much.

The architect of to-day has before him a wide field of choice in the selection of materials for every part of his building, and has the command of the markets of the world for the supply of all that cannot be produced locally.

The electric cable, and the swift steam-ship place within his reach, at short notice, all the resources of Europe and America. [The author here refers in detail to the materials available for building purposes in earlier days, and the methods of using them, and contrasts them with the wide range of choice available to the Architects of the present time, and with the modern improvements in the construction and decorative arts.]

Last, but not least, must we acknowledge with thankfulness those items in our dwellings which so much tend to the preservation of health, and the prolongation of life. As the outcome of much laborious thought, much patience in experiment, and much devoted enthusiasm in the cause, "Sanitary Science" has in the last two decades made giant strides, and conferred untold benefits upon the human race. In the matter of drainage and ventilation, in the construction and fitting of closets, baths, sinks, lavatories, and all necessities for the health, cleanliness, and comfort of our lives, it is almost impossible to overrate the importance of the improvements that have been made during the last generation.

Much of this we owe to wise legislation. In Sydney, as in many other places, the Government has taken upon itself, through properly constituted representatives of its authority, the charge of providing the inhabitants of city and suburbs with a pure and abundant supply of water; a system of sewerage, constructed upon the most approved methods of modern science, and which in its full development will challenge comparison as a triumph of engineering skill with that of any city in the world. Under the same administration is placed the control of the entire sanitary arrangements of every household, and a watchful and rigid supervision is exercised over them down to the minutest detail. Under this beneficent guidance, the dread rule of "the pestilence that walketh in darkness," and of "the destruction that wasteth in noon-day" has been in a great measure arrested, and a marked improvement effected in the death-rate and health returns of the metropolis.

Within the limits of the city proper, the Legislature has provided for a control, vested in the Municipal authorities, of the buildings erected in it. The City of Sydney Improvement Act, which came into force in 1876, regulates the construction of buildings in a fairly effective manner; but outside the city boundaries there is, as far as the writer is aware, no control whatever over the construction of the buildings – every man is left to his own devices—

and the suburbs abound with illustrations of the necessity for supervision of some kind.

Happily the sanitation of suburban buildings is better provided for.

The Water and Sewerage Board has under its control, no less than fifty suburban boroughs, and in all these the same attention is paid to the efficiency of every detail of household fittings as in the city itself.

It is not contended that for all these boroughs there is required a Building Act of the same stringent and comprehensive character as is applicable to a great city; but it will hardly be disputed that the time has arrived when a modified and reasonable control should be vested in the Borough Councils, enabling them to regulate, at least the thickness of the walls, the construction of foundations, the cubic air-space of sleeping rooms, and some of the simpler provisions for preventing the spread of fire.

In the more thickly populated boroughs the necessity for such an Act is very urgent. In those more recently brought into existence it would not, however, be expedient to place too much restriction upon the pioneers of the locality, or to hinder the growth of small enterprises. Hence a Suburban Building Act should be so framed as to come into operation in any particular borough only by proclamation of the Governor in Council.

Much has been written and been said about the necessity for a new Building Act for the city, and it must be admitted that there is great room for improvement.

The lapse of thirty years since the passing of the existing Act should furnish us with a stock of experience as to the additions and amendments required to bring our laws more into harmony with present conditions.

Amongst the questions of primary importance to be considered in the framing of a new Act is that of fire-proof construction more or less complete, closely connected with which is the limitation of the height of buildings, and the number of their storeys.

In legislating on these points, however, much judgment is required, and a calm and dispassionate study of the somewhat conflicting interests which have to be reconciled is indispensable. The view of the expert firemen is, very naturally, a somewhat partial one. He looks at the subject from one point of view only, and his theories, if carried into practice to their full extent, would hamper very seriously the operations of the architect, and place grievous obstacles in the working of the businesses of the merchant and shop-keeper. The costliness of buildings would be greatly increased, and, generally speaking, it is doubtful whether the advantages sought to be obtained would not be too dearly purchased.

It must not be forgotten that high authorities are by no means at one as to the effectiveness of the so-called fire-proof construction of to-day. In the minds and in the writings of those who have given the most earnest consideration to the subject, there is evidently grave doubt as to the possibility of constructing a really fire-proof building. Examples have been frequent of late which prove that buildings which in their construction contain no particle of inflammable matter, and where iron and steel have been protected from the direct action of fire and water, the whole structure has crumbled into dust under the fierce heat generated by the combustion of its contents.

All this leads us to the conclusion that legislators must keep prominently in view the balance which it is imperative to maintain between over much fire-proofing, and our commercial and domestic necessities.

If, within the scope of a Building Act, it were possible to make a settlement once and for ever of the vexed question of "Ancient Lights," what a happy consummation would it be.

The laws affecting "Ancient Lights" in England have their origin in remote periods, and in old customs and rights which have no parallel in this young country. How far those laws apply to the Colony is a problem upon which no two lawyers seem able to agree, and property owners and their architects are embarrassed by the uncertainty which prevails, and which is so eminently desirable to put an end to.

This is not the place to discuss the ethics of the question; but to the writer it has always appeared most inequitable that because a neighbour of mine has enjoyed a privilege for a certain number of years—a privilege that it was in my power to deprive him of at any moment—that he should acquire a right to go on enjoying it for ever to the grievous detriment of my property.

From a citizen's point of view, it certainly appears a thousand pities that in a young country like this, we should be hampered in the building of our cities by laws, which, however they may have come into existence in the old country, have here, at least, no foundation to rest upon which is based upon justice, on expediency, or on common sense.

No. 11.—THE GROTESQUE IN MODERN DEVELOPMENTS OF THE PICTURESQUE.

By Howard Joseland.

(*Read Wednesday*, 12 *January*, 1898.)

[*Abstract.*]

The subject of my paper I have gladly taken up, for the reason that I foresaw, at the commencement of what may be called a new era of Australian Domestic Architecture, that there would be a tendency to run riot in this fresh development.

I have said Domestic Architecture, because, firstly, it is in this branch of our profession that there has been the most marked change; and, secondly, because time would not allow of my touching the more important works; and the principle underlying my argument applies really to all architecture.

The grotesque has at all periods been more or less associated with our art.

The attempts of the earliest builders were rude or grotesque in conception in comparison to those of later times. Then came the grotesque of the early civilised times, brought about partly by the religious beliefs and superstitions of the nations. Next, from the dawn of the Renaissance, can we trace a grotesque of another kind—a grotesque of "unrest' and confusion of styles; and narrowing down the subject to our present day architecture of Australasia, in addition to "unrest," a grotesque brought about by a misconception of, or want of adherence to, the first principal principles of design. Now, if we apply the only true theory—that the highest architecture involves an honest expression of the requirements in each individual building,—then at once we have a standard by which to try the merits of our work.

To define more clearly what is meant by "grotesque" in modern picturesque, one must first of all have an understanding what constitutes picturesque in Architecture. I take it to be a quality ranking a little below that of the majestic, relating to something which pleases the eye in its general composition, without necessarily inspiring us with admiration on account of imposing grandeur.

To attain this effect, the chief points to be studied are a skilful grouping of the various parts, and the suitability of the building for the purpose for which it is built;—and it is in unsuccessful attempts to effect this that the most grotesque results are produced.

The ease with which the more ornamental features of a building may be multiplied leads us into this danger. Picturesque effects almost invariably have to be accomplished by a process of elimination rather than elaboration, the essence of picturesque being simplicity of form and truth of expression.

To trace further the base of a good design, we find that much depends upon the planning, not only as to internal use, but also in disposition as regards the feature of the site. These should have the first consideration.

The plan having been determined upon, we should erect thereon the superstructure, paying special attention to the outline, and working necessary features, such as doors, windows, chimneys, &c., into the most suitable positions for the convenience of the inside, and using such natural features only as give a meaning and expression to the whole building.

Thus, the design will be satisfactory, because it is a legitimate development of the plan.

Unfortunately there is another method of architectural design abroad which is absolutely wrong.

The proper order of design is reversed. It would seem as though an untrained imagination collected a variety of features, it may be good or bad, in themselves, until there was a chance of fitting a plan to them; or perhaps worked in some pet bit of design without the slightest reason for its existence.

The convenience of the building is often, indeed, sacrificed to such fancies; and no matter whether these are beautiful or bad in themselves, the result will be nothing less than grotesque.

If we come to analyse what is at the root of grotesque in picturesque, therefore, we find not only a good deal that is absolutely false in conception, but much that is bad in construction; and in nearly all cases where we feel that a design offends us, whether the reason be at once obvious or not, the real cause lies in the fact that it is forced, and does not honestly and naturally express its purpose.

In order to illustrate my meaning, I have imagined a building composed of a number of such features as anyone may see in many of our suburbs; and I regret to say our new suburbs are by no means an exception.

[Reference to, and sketches of, many instances of false design and construction in recent work.]

Now, not only is the whole design full of grotesque features, but the selection and disposition of materials is worse than grotesque.

The front is of the best quality brick, but the sides and back are the commonest. The roof is of the most expensive slates on three sides, the back and inside slopes are iron.

If the proprietor could not afford to use the best materials throughout, it was the duty of the architect to advise him to adopt less expensive, though, for all practical purposes, equally durable, materials all round.

The examples I have here portrayed are commonplace, I know, but I trust I have said enough to impress upon you the argument which is my excuse for the production of this paper, namely, that grotesque in modern picturesque arises from a misunderstanding of the first principles of architectural design.

I hope, also, I have not wearied you with this nightmare of a vision (as portrayed in the sketches). It would be all beneath notice were it not for the fact that all the eccentricities I have put before you are actually being daily perpetrated by many practising as architects who at the present time have the confidence of the public.

In a young and comparatively-poor country like this, our architecture should be more simple. I would go so far as to say that it is absolutely dishonourable to squander our clients' money in what is not durable, or to introduce needless fads of our own for the sake of seeing them realised.

In conclusion, I would briefly state that it appears to me what greatly contributes to the cause of so much grotesque architecture here, may be accounted for by two causes. One is, that our students of architecture labour under the disadvantage of having no opportunity of studying here the wealth of picturesque examples of actual old work to be found in older countries; secondly, that many of the practising members of our profession have launched forth on their career with less than half the experience and training that is deemed necessary to properly qualify an architect in England.

Our profession is, unfortunately (or fortunately), an open one, for it has been contended by some of our best men that years of the training necessary for examination work would tend to check the artistic sense in architecture. Any way, any sort of recognised test of ability seems as far off as ever.

It remains, therefore, for those who have the best interest of our profession at heart, to persevere, in spite of much that is discouraging, and by the examples of our actual work, rather than anything we can write or say, to show that architecture is something more than an indiscriminate piling up of features, but that it should be a natural expression, not only in general conception, but in detail, of the requirements of the times in which we live.

No. 12.—COAL-MINING IN NEW SOUTH WALES.

By J H. Ronaldson.

(Read Wednesday, 12 January, 1898.)

[*Abstract.*]

In the year 1797 coal was first discovered in New South Wales at or near Coalcliff, 35 miles south of Sydney, and a similar discovery was made a month later at Newcastle, where the coal was worked by the Government till 1829. Convict labour was employed during that period, and the total quantity of coal raised was 50,780 tons.

From 1830 till 1847, the Australian Agricultural Company held the monopoly of working coal under Government land, although coal was to a very limited extent worked by others at the time from alienated land.

The progress made in coal-production throughout the Colony may be gathered from the following figures, which include the outputs from the collieries of the Northern, Southern, and Western districts :—

Year.	Output in Tons.	Year.	Output in Tons.
1831	4,000	1871	898,784
1841	34,841	1881	1,769,597
1851	67,610	1891	4,037,929
1861	342,067	1896	3,909,517

These figures indicate retrogression during the last few years rather than progress, and unfortunately outside competition has also forced down the selling price. From 1875 to 1885, the value per ton of coal exported dropped 24 per cent., and from 1885 to 1895 33 per cent., or, in other words, the price obtained in 1895 was less than half that obtained in 1875.

The causes conducing to this state of affairs show how ill-advised the efforts of labour leaders have proved in seeking to regulate the workmen's earnings without due regard to the potentialities of outside competition.

To the output of 1896, the Northern, the Southern, and the Western contributed respectively 67 per cent., 26 per cent., and 7 per cent.

THE NEWCASTLE COAL-FIELD.

The Measures of this field dip generally towards the south, and, omitting the unproved strata of the Stroud district, are divided stratigraphically into the Greta, the Rathluba, and the Newcastle groups, occurring in ascending order as named.

The Greta or lowest group laps around an anticlinal dome of intrusive rock that occurs 27 miles north by west of Newcastle, and on its western side the Greta seam has been worked for many years. This seam at its best has been found 18 feet thick, and yields a clean, hard, flaming, non-caking coal, unsurpassed for household use and somewhat singular in its characteristics. In one small part of Greta colliery this seam contained a shale particularly rich in hydrocarbons. To the south and east of the anticline this seam has been opened up and, in places, found of great thickness and of excellent quality. Northwards its extension is unknown.

The Rathluba series, separated from the Greta group by some 800 to 1,000 feet of strata, and itself from 700 to 1,000 feet thick, contains various thin seams of coal which, although of a quality inferior to the Greta and the "Borehole" seam of Newcastle, are worked to a limited extent in the neighbourhood of East Maitland.

The Newcastle series overlies the Rathluba, with 1,000 feet of intervening strata, and is found cropping up in a line running north-west from the town of Newcastle for a distance of 16 miles, while to the south beyond the limits of the existing collieries its extension is ill-defined.

In this series are found some eight or nine seams of coal, some of little present or prospective value, while others not now worked will become valuable in time to come.

The lowest workable seam is the well-known "Borehole" seam, which for purity and general usefulness occupies the premier position among Australian seams. The coal is strong, bright, and bituminous, excellent for household and gas-making purposes, and of good quality for steam-raising. It contains 36 per cent. of fixed carbon, 57 per cent. of volatile hydrocarbons, and $4\frac{1}{2}$ per cent. of fixed ash. In and around Newcastle this seam occurs under most favourable conditions for working, is from 5 to 15 feet thick, has a good roof and floor, and is free from explosive gas.

To the south of Newcastle, on the shores of Lake Macquarie, the Pacific Colliery is working one of the upper seams, which, being thick and easily won, is able to compete at a lower price with the "Borehole" seam. Further south, and 16 miles from Newcastle, at Catherine Hill Bay, the Wallarah Company is working one of the thick upper coals whose identity is scarcely determined.

THE SOUTHERN COALFIELD.

Many years subsequent to the establishment of the Northern coal industry, the "Bulli" seam was opened out at Mount Keira, on the side of the mountain range overlooking Wollongong, and at later periods one colliery after another was established in the district till now ten fully equipped collieries are in more or less active operation.

The seams of this coal-field crop out on the ranges facing the Pacific Ocean and are thus exposed from Jamberoo to Coal-cliff, where they disappear beneath the ocean level. Seven miles further north, the "Bulli" seam is found at a depth of 641 feet below sea-level, and extensively worked by the Metropolitan Coal Company from a shaft 1,098 feet deep. At Mount Westmacott, $3\frac{1}{2}$ miles to the north, and at Holt-Sutherland, $16\frac{1}{2}$ miles from Sydney, this seam is found at depths of 1,518 and 2,231 feet respectively.

Recent boring operations at Cremorne, on the northern shores of Sydney Harbour, proved this seam at a depth of 2,900 feet, the core in the first bore showing a 9-feet seam of wholly burnt or cindered coal, and in the second bore an apparently clean and unburnt coal. Tempted by the geographical position, a company is, on the strength of these two bores, sinking two large shafts, $2\frac{1}{4}$ miles west of the bores with the object of working coal under the waters of Sydney Harbour.

The "Top" or "Bulli" seam is practically the only one of this field hitherto worked, the remaining six or seven underlying seams being either commercially useless, or at best distinctly inferior. Mount Kembla Colliery marks the southern limits at which this seam is of commercial value. Found there as thin as 2 feet 9 inches, it rapidly thickens to the north, and throughout the greater portion of that property it exists 5, 6, and 7 feet thick; northward to Bulli it exists 6, 7, and 8 feet thick; at North Bulli it thins to 4 feet, and again gradually thickens northward till at Helensburgh it attains a thickness of 10 feet.

This seam is semi-bituminous, and unrivalled in the Colony as a steam-coal. It contains 66 per cent. of fixed carbon, 22 per cent. of volatile hydro-carbons, and 9 per cent. of fixed ash; it yields an excellent hard-bodied coke, now largely used in metallurgical works in Australasia.

THE WESTERN COAL-FIELD.

This field is readily correlated with the Southern field. Its coal and kerosene shale-beds are found in the elevated plateau of the Blue Mountains, their continuity with the Southern (or Eastern) coals having been abruptly broken by a large dislocation in the strata, caused by a sinking of the land to the east of these mountains. The coal is cheaply won and cheaply sold. Although containing more ash than the Newcastle or even the Southern coal, and distinctly less valuable than the latter for steam-raising, it gives fair results, and has of late been largely patronised by the Government railways.

It is in isolated and circumscribed areas of this field that the famous "Kerosene" or "Boghead" shale occurs, its finer quality being exported for gas-enriching. The second quality, hitherto used for oil-making, is now, on account of the free importation of American oils, thrown aside or left unworked.

To summarise, we can trace the seams of the Southern coal-field along the South Coast Ranges from Jamberoo, 70 miles south of Sydney, to Coalcliff, within 35 miles of Sydney; northwards by means of the Metropolitan Colliery, the bores at Mount Westmacott, the Holt-Sutherland Estate, Liverpool, and finally at Sydney.

From Sydney northwards a hiatus in our knowledge exists, and we must travel on past the bores at Wyong to Catherine Hill Bay to reach known ground. In this long gap of 70 odd miles, changes in the character of the coal-seams and the enclosing rocks are inevitable, and render the relation of the Northern to the Southern coals a matter of speculation.

METHODS OF WORKING.

Of the two systems of coal-working—pillar and stall, and longwall—the former has been with a few exceptions exclusively employed in the Colony, and it is to be regretted in many cases with little regard to fundamental principles. Impatient owners and anxious managers have too frequently, with short-sighted economy, left pillars of too small size, resulting in irretrievable loss of coal and in danger to human life.

In some of the shallow mines of Newcastle the unaltered methods of half a century or more have held their sway, and bords of 8 yards and pillars of 4 yards width have been the rule. A somewhat similar state of affairs has obtained in some of the Southern collieries, where perhaps some justification may be admitted on account of peculiar parallel "rolls" of stone on the floor between which, for economy, the bords or stalls are driven. In other Southern collieries, pillars 12, 16, and 20 yards wide are being left in the first working; and in one notable instance—the Metropolitan Colliery—pillars 250 yards long and 50, and at times 100, yards wide are left where, on account of peculiar conditions not altogether dependent on depth, smaller sized pillars are objectionable. In some of the newer collieries of the North, 8 yards pillars are the rule.

Longwall, with its many advantages under certain conditions, has only been adopted in a few instances.

It cannot but be matter for surprise that in a country like Australia, where miners' wages rule high, and where in its oldest and chief coal-field the hewing rate constituted by far the highest item in the winning cost, little or no effort has been made to introduce coal-cutting machinery; and it is the writer's belief that, paradoxical as it may appear, the miner's best hope of maintaining a high level of wages lies in the adoption of labour-saving appliances that may enable the colliery companies to compete with outside rivals.

VENTILATION.

Coal-mining has progressed in no direction more rapidly during the last half century than in the methods and thoroughness of ventilation. Instead of the 10,000 and 15,000 cubic feet of air per minute considered ample to ventilate a colliery in the earlier years of the century, it is not unusual for one fan to circulate 400,000 cubic feet of air per minute through the airways of a colliery. The splendid fan of the Metropolitan Colliery in this country readily circulates a current of 300,000 cubic feet of air per minute through the workings.

Although the above quantities are exceptional, it is to the magnificent achievements in colliery ventilation of recent years that must be attributed the well-established fact of a collier's occupation being now one of the healthiest in the long list of industrial pursuits.

Ten years ago nearly every colliery in New South Wales was dependent on underground furnace for ventilation ; to-day there are some ten fans in the Northern and three in the Southern district.

Fortunately the collieries of New South Wales have hitherto been exceptionally free from explosive gas, and in only one colliery, the Metropolitan, where a highly explosive gas of a peculiar character is met with, has it been found necessary to use safety lamps continuously. No doubt when the dry and gassy coal under Sydney Harbour is reached, much gas will be given off, and great care will be necessary in its ventilation.

The investigations carried on of late years have demonstrated the danger that exists, even in the absence of explosive gas, from the presence of dry dust, due to the attrition of coal and certain kinds of rock, and deposited on the floor and timbers of roadways when ordinary powder and many other explosives are made use of for blasting. That many otherwise inexplicable explosions have occurred from this cause is now universally conceded, and the remedy lies, where blasting is necessary, in the use of the safest explosives, removal of the neighbouring dust, and liberal watering.

Ten years ago the disastrous Bulli explosion occurred, and there are now few intelligent men versed in this subject who doubt that, however begun, its propagation throughout the roadways of the mine was due to the presence of dust.

In this *résumé* of the writer's original paper, it has been necessary, not only to condense, but to excise many portions, leaving only sufficient to indicate very briefly some of the chief features of the subject.

SECTION I.

SANITARY SCIENCE AND HYGIENE.

PRESIDENTIAL ADDRESS.

By the Hon. ALLAN CAMPBELL, M.L.C., L.R.C.P., L.F.P.S.

(*Delivered Saturday*, 8 *January*, 1898.)

ASPECTS OF PUBLIC HEALTH LEGISLATION IN AUSTRALIA.

I APPRECIATE the honour extended to me by the Council of the Association, and deem myself fortunate in having an opportunity of addressing the members of the Association and the public in this important section of its work. Let me, however, at once say that I am no specialist in hygiene or sanitation. My interest in them comes to me as side questions, more in the part I play as a representative of the people in Parliament than as a medical man, or as a sanitary expert. This will account to some extent for the turn the discussion will be found to take in my address. I am conscious of a total lack of experience in any of the duties pertaining to an officer of health, and were a President's address limited to a technical review of the important questions with which Section I deals, I should feel bound to give place to someone with a larger experience, and more opportunity of concentrated study than has fallen to my lot.

The discursive character, I apprehend, of a Presidential Address, renders it capable of popular treatment. It is not supposed to necessarily limit itself to matters exclusively within the province of the specialist, or to be addressed to experts only. A fair measure of license is given to range over the wide field of topics which the section embraces. Under these circumstances facts and theories will be referred to familiar to professional men. When, however, it is remembered that in this Section, more especially the questions we deal with, have large public aspects

we must not hesitate, even at the expense of repetition, to restate the principles of our science. We all know that there is little danger of repeating them any too often in the hearing of the public. Those, therefore, of my audience, who are more intimately acquainted with hygiene and sanitation than I am, will bear in charity and patience the scientific shortcomings of my address.

The task I have set myself is practically an appeal to my fellow legislators of these colonies, and however Utopian the effort may seem to some, this can be said for it, that it is neither illegitimate nor out of season. I propose to limit myself to the consideration of the three following general propositions:—

1. How far public hygiene claims attention from our legislators.

2. What Australia has on general lines accomplished in the direction of public hygiene and sanitation.

3. What remains to be done, and the lines on which immediate legislation should run.

SECTION I.

The recent unique historical event, a Diamond Jubilee of the reigning Sovereign of the British Empire, has thrown many scientists and philanthropists into a somewhat retrospective mood, and we have been favoured with excellent and highly-interesting monographs, detailing the progress of science and art, and the development of social movements during the last sixty years. None of these have been more interesting, and none have shown greater advances to have taken place than those relating to public hygiene. Its triumphs have been more than ordinarily manifest, and these have only been made visible as the theoretical conclusions on which it is based have become more completely embodied in legislation. Public hygiene really can have no practical existence without enactment. It may seem to minds trained to methodical reasoning an easy process to utilise the conclusions of a branch of science so experimental as that upon which public hygiene rests, and to secure their materialisation, so to speak, in law. But when it is remembered that these conclusions of science must filter through minds, whose strong point is not the calm exercise of the reasoning faculty, the barrier to securing an Act of Parliament is substantial, and the labour involved in overcoming it hard, and oftentimes disappointing.

But legislation has to be obtained. It is said, public opinion must be followed, but it is equally true that it must be created. It is the work of knowledge to create, and that is the aim of this Association to-day. In seeking legislation, the main factor after

all is, not so much public opinion, but the intelligence of the average representative of the people. He has been a study to me for many years. He is a compound of many influences, and the subject of the most diverse motives. Nevertheless he makes our laws, and determines the legislative limits of our aspirations for the public good. He must be approached with consideration. The clearest demonstrations of science will not compel his assent. We must exercise discretion, and clothe our advances in accordance with his habits of thought as a politician, and not as a savant or a philanthropist, although none knows better than I do, that there is much in his labours that exhibits both practical wisdom and philanthropy.

Possibly his attitude of semi-indifference towards public hygiene may be from several points of view excusable. In its scientific aspect it is itself largely only of yesterday, while the organisation of its principles under legislation involves considerable public expenditure, and at the same time impinges upon individual liberty, of which he is very suspicious. Yet Australian legislation generally suggests the reflection that we in the Southern Hemisphere are again bent upon proving how far compulsory or mandatory laws can be instituted among a free people. We can see this in various directions. While, however, admitting that public health legislation must to a large extent be compulsory, it is needful that I should point out that compulsory legislation for this purpose has features which distinguish it from compulsory legislation for purely economic objects, and unless the difference between them is recognised, the objection to compulsion must lie against the one as well as the other. How far law may trench upon the liberties of a free people, it is not possible to put in a general proposition. Every encroachment must rest upon its own basis; but so long as that basis is broad enough, no apprehension of its effect need be seriously entertained. At the present moment throughout some of the Australian Colonies, legislation is being passed interfering considerably with industrial freedom. It is not my purpose to inquire what may be the issue of this; I desire merely to take note of the tendency; and while drawing attention to this spirit of the time, I wish to make it apparent that compulsory legislation for public health purposes is not outside but rather very much within the range of this prevalent idea.

After all it is only in so far as any system of compulsion among a free people can be rationally defended that it has any right to exist. Public Health laws have the broadest possible basis; they touch every member of the community. Public health is equivalent to national well-being, and national well-being is certainly the welfare of the whole and not of a few. Its legislation prejudices no one in the end; and with whatever

irksomeness its mandatory provisions may be received by some, no class and no individual of any class goes under in consequence. I claim on behalf of public health laws, that although they come within range of the spirit of a time which hankers after compulsory legislation for economic purposes, they are the one phase of that legislation which can call to its defence sound reason, and a guarantee of fair play to all. Compulsion at any time can only be deprived of its apparent tyranny by its inherent reasonableness, and applied to the legislation I should like to see established, it simply means the parting with a partial and oftentimes injurious freedom for a fuller and a higher form of liberty.

Surely, therefore, I may approach my brother representatives of the people, and claim an attentive hearing on behalf of more complete public health enactments than now exist. It is no doubtful claim that such enactments are but part of the modern movement which is lifting the masses and ameliorating the struggle for existence. Philosophers have called it the altruistic movement, but the spirit of it is the lessening of human misery, and the enlargement of the possibilities of a better life to all. There cannot be any question of the supreme importance to everyone of the possession of health; but much more important is its continuity to that large class of men and women, whose chances of securing the necessaries of life are so limited as to leave, when health is gone, but a small reserve between independence and poverty. Under conditions of poverty the struggle is neither fair nor equal. Writers on social evolution, and political leaders of all creeds, never fail, now-a-days, to remind us that the whole trend of our social advancement foreshadows a larger and more righteous equality of opportunity for all. If this be so, then the question of public health legislation is lifted into a position of supreme importance Such an equality is but a dream to the masses without securing to them the possibilities of health.

But we may also look at Public Health legislation from the economic as well as the altruistic standpoint. Some of its problems can be set out in figures as clearly as the balance-sheet of a business concern. National Wealth and National Husbandry, if not absolutely convertible terms are nearly so. Adam Smith tells us industry is the true source of wealth; but steady toil lies at the basis of industry and health at the basis of toil. A healthy nation also industrious is on the high road to wealth. It is this condition that alone makes for a high standard of comfort, and as the social writer phrases it, makes possible the maintenance of a life worth living.

We have not the data at our command in the statistical records of Australia to set out fully the gains which an intelligent system

of Public Health administration may secure. The fact is we have had no experience of such a system. We must turn for data to older communities which are in advance of us, and no country has led the van more than England. At a meeting in June last in the Guildhall, London, (Dr.) Sir Richard Thorne, summarised the position in a very able and remarkable address. Referring to the danger of unduly exalting the achievements of Public Hygiene, in which he himself had had a leading hand, he said "What do others say of us? A few years ago a distinguished Frenchman, M. Henri Monod, Director of Public Health in the Ministry of the Interior in Paris, impressed by the waste of life in his own country, set himself to study the results of English Sanitary Administration, and he showed that if during the ten years 1880–1889 our death-rate had remained the same as it stood before that date, we should have lost over 800,000 lives during those ten years. For the purposes of this eventful gathering, I have brought these French studies up to current date, and I find that if they are carried to the end of 1895, the saving of human life since 1880 amounts to close upon 1,500,000. That, I venture to maintain, is a grand achievement, and it was as such that it was submitted to a body of French experts for imitation." He continues "Is this all? Both preventible disease and death are very pitiless in their incidence; they select the young and the bread-winners, and they wreck homes and families that were full of hope. Sir John Simon, once calculated there were 125,000 more deaths in England and Wales every year than there should be. Allow only ten cases of non-fatal disease for one that terminates in death, and we have an annual total of one and a quarter million cases of sickness, often involving misery, penury, and even pauperism. The saving of life, calculated on the basis of my French friend and colleague in the fifteen years ending 1895, means a saving during that period of 15,000,000 attacks of sickness." He concluded by these words, suggesting the economic aspect of the question, "Surely the financial aspect of this great operation can be appreciated in this, the financial centre of the world." The saving here referred to by Dr. Thorne has been calculated by others, to amount to a saving of no less a sum to England than £15,000,000 per annum.

In an industrial nation every human life is an integral part of the nation's wealth, and every death from preventible causes is a loss in money value. The cost of the ravages of preventible diseases can therefore be calculated. Every colony can sum up its own balance-sheet. In South Australia, during 1896, there were 93 deaths from typhoid fever alone, in a population of 300,000, and taking the ordinary basis of calculation for non-fatal cases, and even leaving out the deaths and cases of sickness of the non-working ages below fifteen and over fifty-five, and the typhoid

bill of South Australia was nothing short of £30,000; but there were deaths from other preventible diseases than typhoid fever, amounting in all to 619, and, looked at from this point of view, the loss inflicted during that year upon South Australia, could not be less than £200,000.

These figures, although presented with great brevity, must emphasise to our representatives the fact that public hygiene is not merely a financial question in virtue of public expenditure, but more because of the national loss its absence entails. If the standard of public health is a high one, the nation's gains are great, if the reverse, its losses are enormous. Lord Playfair was amply justified in saying, at the meeting in the Guildhall to which I have already referred, "That no community could make a more advantageous investment, than to spend annually in proportion to its population, a few thousands, or hundreds of thousands in securing the best standard of public health."

But I may be permitted to offer our legislators another consideration. It is frankly admitted that not many years ago, great diversity of opinion existed among those who were credited with knowing the origin and nature of preventible diseases, with the usual result that the public were left in uncertainty and the victims of superstition. It may be remembered as an historical fact by some here, that not later than 1832 a Bill was introduced into the British House of Commons with the preamble "Whereas it has pleased Almighty God to visit the United Kingdom with the disease called Cholera, &c," and although science disclaim any such theory as to the origin of disease, for many years even after 1832, it spoke of hidden cosmic and telluric influences as the agents at work in the production of those desolating epidemic visitations.

All this is now changed, hypothesis has given place to fact, and uncertainty to knowledge. The secret has been discovered, and new light has at last been shed on a hitherto dark and mysterious page of nature. To the germ theory of disease belongs the credit of this transformation. But it is no longer a theory, it has become a science. During the last twenty years bacteriology has laid bare the minute and living organisms, to whose activity so many of the ills of our race are due, and it has become the repository of the facts and generalisations that constitute the basis of the present day principles and practice of Public Hygiene. These living organisms, it is true, are subtle and minute, but no mystery attaches now to the conditions of their life or their management. They are ponderable bodies, subject to physical law, and there is no uncertainty as to the course they will, in any circumstances of important practical moment, pursue. If they are present in a liquid medium they will precipitate or remain afloat according to their specific gravities. If they lie upon a moist surface, they will

not rise with the evaporating moisture. If they become dry, they will be disseminated only by such air currents as are of sufficient force to lift them into the atmosphere. This material property of germs then is a fundamental conception, and forms the basis of the chief practices of Hygiene in connection with communicable diseases. It is a conception too that divests these germs of all mystery; it is easily grasped by the public mind, while it is more than sufficient to satisfy the public judgment on the reasonableness of the means prescribed by Public Health legislation for their control and destruction.

The power of these minute bodies or microbes to produce disease is beyond dispute. Their vitality is very real, in fact in some of them, it is positively tenacious. They attach themselves to different structures in the body, find for themselves a suitable soil, and multiply with amazing rapidity. The process is not identical in each kind, neither are the conditions on which their developments is dependent the same in all, but the fact that they are living, ponderable bodies, with a life history singularly distinct, is applicable to all. It is not assumed that nothing now remains to be known regarding them, for that would not be true, but so far as public health is concerned, every practical point is covered by the knowledge now acquired.

It only remains for me in this first section of my task to say, that these germs or microbes are the efficient causes of those wide-spread and well known diseases as Typhoid Fever, Diphtheria, Tuberculosis, Influenza, and many others, which every year in this bright land of Australia destroy so many lives. These microbes are known to be specific, they never lose their identity, or produce a disease other than the one from which they have been derived. They are as separate in their natural history as species of animals and plants are. Their qualities of ponderosity, vitality, and specificity render them readily conveyable from one human being or animal to another. These attributes also form the basis of their infectious or communicable activity, while at the same time, having due regard to classification, they guide the selection of the means necessary to combat their virulence and stamp out the diseases they produce.

Such knowledge has been gained only by patient and self-sacrificing labour, and it is this knowledge which alone can safely guide legislation. It can no longer be left out in Public Health Administration. Our representatives cannot, therefore, remain indifferent to the claims of modern Hygienic Science on behalf of the people, neither can they remain any longer unconscious of the power they possess to pass intelligent and efficient laws against public enemies so subtle, so active, and so mighty.

SECTION II.

I have now to refer to what Australia has to say on the progress of sanitary work among her numerous communities. I am persuaded she can say more to-day than she could have ventured upon saying even when this Association was founded ten years ago. We are certainly unable to boast of achievements such as characterise the movement in England and several leading Continental nations, or in some of the United States of America; but we may, nevertheless, take heart, and rely in good faith upon the assumption that at least our steps are towards the rising sun. It is true we have all the scientific knowledge at our command which is in the possession of these older countries, and with this knowledge we have evidence in the many reports issued by State Health Boards of the presence of men amongst us who are not only conversant with every modern phase of scientific hygiene, but also keenly alive to the necessity of progress. But here, as in many other State affairs, sanitarians must wait upon the people's representatives to afford them, by legislation, a plan of action.

Every man who may in some degree be acquainted with the outlines of the history of Australia will be ready to admit that there is something to be said in extenuation of our backward position. The early days of colonisation were times of struggle: sustenance for daily consumption was the immediate and most pressing necessity. So soon as settlement extended, the question of communication and interchange came next, while the organisation of social order and defence from internal enemies followed. The city in which we are now met may be taken as typical of the early days of settlement. The first settlers on these shores landed upon virgin soil. They entered into the enjoyment of a delicious atmosphere, a mild winter, a delightful spring, and a fairly moderate summer. All their surroundings were undefiled, fresh from Nature's hand. For fifty years they paid little or no heed to hygiene or sanitation. They brought with them from the old country certain ideas and habits, and however much England of a century ago began to leave these old ideas behind, the settlers here knew nothing better. Their descendants perpetuated the habits of the dark ages of hygiene. The increase of rural settlement, however, the growth of city life, the exhaustion and defilement of the water supplies, the pollution of the soil and the air, and the accumulations of filth and refuse, made deep and serious inroads upon the health and mortality of the people. They were compelled to pay some attention to the question of better sanitary surroundings. Sydney was founded in 1788, yet the sanitary arrangements sixty years afterwards were of the most primitive character. Up to 1850 the water supplies of a large and ever augmenting population were obtained from wells, or some

domestic catchment. The old cess-pit existed unchallenged during that long period, and for some years afterwards in many places, while scavenging was practically unknown. The atmosphere was polluted by the presence of noxious trades in the very heart of the city. The creation and securing of wealth shut out every other consideration of a less material nature, and the people did not awake from their lethargy, until death had found them "ten thousand several doors for men to make their exits." The new Corporation of Sydney, under the Act of 1857, it is said, worked wonders for its welfare, although at the same time, history admits, it was only about ten years ago that an ample supply of wholesome water was found for all its citizens. However, if the leading requirements of every large community are enumerated, it will be found that she is well abreast of any city anywhere.

The capital city of Victoria followed much on the same lines, with the exception that in its water supply it anticipated this city by many years, while in its drainage system it has been as many years behind. Within the last three years, as we are all aware, a drainage system on the most modern lines has been inaugurated, and when completed will place Melbourne in the front rank of well-sewered cities. For many years Adelaide has had both water and sewerage in excellent condition, and has been acknowledged by visitors generally to be the cleanest city in Australia.

We cannot, therefore, be said to have remained inactive in securing improved sanitary conditions for our largest populations. If we take into consideration the large expenditure involved in carrying out the engineering works necessary to meet their requirements in respect to water and sewerage, it will readily be conceded that advances have been made towards better sanitary conditions than was to have been anticipated even a few years ago. There are good grounds for some degree of satisfaction, when it is recollected that Sydney has expended £4,154,000 upon its water supply, and £1,892 000 upon its sewerage arrangements; that Melbourne has spent £2,400,000 on its water supply, and on its drainage system, when completed, upwards of £5,000,000; and that Adelaide, small as it is, has on each of these works, spent respectively the sums of £1,491,000 and £516,000.

It may be said, that a water supply and system of drainage are necessities of city life, and, apart from the question of health, would come into existence on grounds of convenience or from business motives; still without them, city life would be intolerable in the long run. Water supply and sewerage are fundamental requirements, and must exist if sanitary conditions are to be maintained. Whatever may be the details of an organised system of public hygiene, these must exist as a basis. In the present condition of these cities, there is certainly some grounds for congratulation, and future hope of still better things.

I cannot speak so favourably of the condition of rural Australia. Some writers, I find, say there are elements of encouragement in the existing state of things, and that it is not a vain hope to believe that broader hygienic ideals will yet take hold of the local governing authorities, and lift the sanitary position of the country districts to a higher level. Meanwhile, it is to be feared, the fact is only too patent, that in the larger number of rural communities, very primitive and insanitary conditions prevail. In many instances the functions of these Local Health Authorities seem to be exhausted in the abatement of glaring and offensive nuisances. Municipal communities have been moving forward, but rural districts have been stationary. The hope of reaching these authorities lies in better and wiser legislation than we have yet had.

There are many agencies at work in this country, pressing towards a higher sanitary ideal. The mingling of health topics in our various systems of public education, the existence of centres of instruction, established by the St. John's Ambulance movement, all over the colonies, the labours of scientific associations and popular health societies, the dissemination of useful information by the Press, the organisation of several forms of charities, especially hospitals and trained nursing institutions, all conspire to create and extend a mass of simple knowledge among the people that must inevitably bear practical fruit; and let us also hope, that by the same means, the attention of our legislators will be arrested, and the necessity for the embodiment of a higher legislative ideal will speedily become apparent to them also.

The influence of our hospitals should be powerful in the direction indicated. These institutions should certainly be able to lift the public mind from the rudimentary notion that the administration of the public health consists in something more than the removal of a disagreeable odour or a heap of rubbish. They should be competent to teach the fact that isolation, ventilation, disinfection, drainage, and pure water are, anywhere and everywhere, the conditions necessary to secure safety from some of the most fatal diseases that afflict our race. The construction and practical working of our hospitals should illustrate every advance in modern hygiene, and, doubtless, many of them do. They crystallise to the public the best scientific ideals, and are true object lessons to those whom it is our earnest desire to enlighten.

It is not necessary for me to detail the admirable illustrations in this city and elsewhere in Australia of hospital architecture, construction, organisation and management. No doubt when the new Fever Hospital takes shape in Melbourne, it will be an exposition of the best hygienic views of the day, and Australians generally will be proud to model smaller structures with further

advances upon it. I may be pardoned for drawing attention to a modest institution in Adelaide, known as the Children's Hospital. It has always had an ideal, and it has always maintained it. While treating disease, it has never lost sight of its duty to educate the public. It has been a training institution for nurses since its origin, and yearly distributes, by courses of popular lectures, important information on health topics. During the past year it has spent £8,000 on buildings and land, in the erection of a handsome bacteriological laboratory and a series of isolation wards. The laboratory was established in a small way two years ago, but the work it has done has given it a leading position in the organisation of the hospital. Similar laboratories have been, or are about to be, established in this city and in Melbourne. This cannot fail to exert a powerful influence upon the public, and promote the perception that infectious diseases must be controlled and their destructiveness opposed by weapons such as modern science dictates. The tangible and demonstrably advantageous results of the combination of isolation wards and bacteriological investigations must before long direct the public mind, and, let us further hope, mould into an intelligent and more modern form the hygienic conceptions of our legislators.

There is a kindred agency to that of the hospital which I should like to refer to. It may seem a trifle in an address before a scientific audience, but it appears to me to be an agency full of promise, and one calculated to carry into effect the details of public hygiene in a manner impossible to be provided for by law. I refer to the use of trained nurses among the sick poor in their own homes. The law may command, but men and women however poor are free agents, and if cleanliness in all their surroundings as well as the early recognition of communicable diseases is to become a part of the daily experience of the poor then the intelligent and the trained must bring it home to them. Trained nurses are exactly the agents required for this service. An amendment made last year in the Public Health Act of England provides for the employment by corporations and local councils of trained nurses as public health officers on the same footing as inspectors. Their constant contact in a friendly way, with the great body of the people, and more especially those who interest themselves least in hygiene, enables them to exercise not merely a beneficent but likewise an educative influence on the poor, and at the same time, by the timely recognition and separation of infectious cases of disease, they confer a precious boon upon the rest of the community generally. We are not behind in Australia in charitable institutions carrying on the same good work, but we have not yet risen to the full perception of the large advantageous possibilities to public health that lie in this new province of woman's work.

I have now set out the general character of my second question —What Australia has done on broad lines in public hygiene and sanitation. The indications of a preparedness to advance are evident in numerous directions. The natural basis is ready, and everything seems hopeful for the more scientific forward movement, for which modern bacteriology has so nobly paved the way.

SECTION III.

Legislators of some experience must have found in every general Public Health Bill brought before Parliament, that defining the powers and responsibilities of the State or Central authority on the one hand, and those of the local authority on the other, constituted the crucial point in the Bill, and more particularly in so far as the relative powers of each bore upon the control and administration of infectious or communicable diseases. Clearly a large amount of sanitary work exists in a community independently of this, the apportionment of which raises little or no difficulty. Whether the central authority or the local authority shall be entrusted with the administration of the public aspect of these diseases is the problem on which turns the immediate future of Public Health legislation. It is fortunate for its solution that it is upon this very class of diseases that the achievements of science have shed the greatest light, and upon which bacteriology is prepared to give the most practical advice.

Communicable or infectious diseases are recognised as preventible, and it is because they are preventible the responsibility is laid upon those who are entrusted by the law to conserve the public health to give special attention to their management. These diseases are preventible in the sense that they cannot come into existence without the agency of certain germs, which bacteriology affirms are capable of control and extinction. In other words imperfect health may exist, and diseases of a serious nature may affect the human body, but such conditions of health will not bring about any communicable or infectious disease unless microbic life be present. To handle intelligently, for the public safety, this prolific source of disease, means the application of the principles of modern hygiene on a large and effective scale. It is therefore of the utmost moment to decide in whose hands this function should rest. To assist in the solution of the problem, the following *a priori* considerations are submitted :—

1. The natural history of microbic life suggests the recognition of two points, their origin or natural history, that is, their mode of existence outside the human body, and their pathogenetic history, that is, their existence in the body as the immediate cause of disease. It is well known that certain insanitary conditions favour the growth of microbic life, and even lend special

virulence to its action. Insanitary conditions also produce depressing effects upon the human body and lower its powers of resistance. Germ-life possessed of this special virulence may attack the healthy, or the individual may fall a victim more by reason of loss of resistence than by the special activity of the microbe. These insanitary conditions then are essentially local, and although they exercise a considerable influence in the production of infectious diseases, it must be the duty of the local authority to deal with them.

2. The sources of communicable diseases are in numerous instances not local but general, that is, they are not limited to the jurisdiction of one local authority but have relations to many. Water supplies are frequently in this sense general, food supplies are almost always so, and where infection extends from one person to another there is a general character in this source also, from the fact that facilities for travel and intercommunication are so easy and so numerous that diffusion rapidly takes place from one locality to another. In this respect communicable diseases must fail to be controlled by local authorities. Their management to be effective is clearly a function of a central power.

3. The extreme readiness with which many infectious diseases may be diffused suggests at once the necessity of prompt action. But promptitude is not usually a characteristic of minor and isolated bodies in authority. Too frequently local considerations based on personal relations to the individuals affected paralyse action, and all the more certainly if several authorities are bound to co-operate. But delays are cruelly dangerous. The area of infection speedily enlarges and irretrievable mischief arises to the public health. It is evident if a combination of circumstances so directly tending to inaction are to be effectively controlled, then the authority must be central and not local.

4. This efficient control likewise requires not only prompt administration but the collateral aid of a well equipped bacteriological laboratory. The work of this new department has become the basis of public hygiene, and at the same time a principal agency in the defence of the public health. Whatever researches of a theoretical nature bacteriologists may pursue, their labours in connection with the public health are essentially practical. A mere enumeration of these labours is at once sufficient to indicate their supreme importance in directing the practice of public hygiene, as well as to show the indispensible position to which they have attained in the management and control of infectious diseases. They may be set out somewhat as follows :—

(*a*) The examination of ordinary products, such as food, water supplies, air, and soil.

(*b*) The examination of the normal tissues, secretions, and excretions of the human body.

(*c*) The examination of the tissues, secretions, and excretions in diseases such as diphtheria, typhoid fever, tuberculosis and many others for etiological purposes.

(*d*) Examinations for the purposes of determining the cessation of the disease.

(*e*) Examinations for the purpose of determining the best means of counteracting the effects of the disease on the body, and of employing disinfectants for the destruction of microbic life outside the body.

The value of work of this character lies in its accuracy. To be able to exclude every source of error in its results, ample appliances of the best construction, with personal skill and extended experience in their use, are indispensable. The strictly scientific nature of the work done, the ramifications of the investigations made, and their broad relations to the whole community, point without doubt to the central or State authority as the one solely fitted to establish and maintain so prime an auxiliary to public health administration.

5. A few words more on this point. It is always, at least it ought always to be, a consideration with legislators how far the laws they wish to frame will meet with an intelligent response in those to whom the State proposes to entrust its powers. As a matter of fact, the amplest powers may be vested in a local authority, but unless there is a rational congruity between the function demanded by law and the intelligence that is to exercise the powers under it, a hiatus will arise, and the law will be found to be practically a dead letter. Whether this intelligent sympathy with the scientific services which modern hygiene is prepared to render exists sufficiently strong among local authorities to induce legislators to place the whole matter of public health in the hands of sub-divided authorities will best be decided by inquiry. But this may safely be predicted of the position, that where the action of local authorities shows that no such sympathy exists, and by persistent evidence is not likely to exist, then the authority by whom these investigations should be conducted, and with whom their practical application should rest, will not be difficult to determine.

These are a few of the reasons arising out of the nature of communicable diseases which indicate the lines on which future legislature should run. It will now be of advantage to learn how far existing legislation in Australia, in its methods and practical results, contributes to prove similar conclusions. Acts of Parliament, not being automatic, must be given effect to by some authority in whom the State vests powers for that purpose. The attitude of that authority towards the exercise of these powers will necessarily indicate its capacity and fitness for the function entrusted to it. If the administration is lax, indifferent, or

altogether deficient with the appearance of protection, the public health becomes the sport of every infectious disease that comes along.

The most typical illustration I can adduce of the position of public health legislation, extending over a number of years, is to be found in the last report of the Central Board of Health for the colony of Victoria. The Health Act in Victoria has been in operation since 1890. It is admirably drawn up, and makes provision for the notification of infectious diseases, and their subsequent management; for the inspection of food and other supplies for human consumption; and is altogether a model Act. The feature, however, that demands our attention at this moment is, that all duties and powers are lodged in local health authorities, with a central authority for supervising purposes. If legislation on these lines were capable of being made effective, then, to my mind, Victoria, by virtue of its comprehensive and intelligent Health Act, and also the acknowledged public-spiritedness of its community, would make it so; but the words of the report I have referred to do not support any such expectation. Its words are: "Protection against communicable diseases is still of a most imperfect sort. As yet, but scant means have been provided for the isolation of persons suffering from infectious diseases; indeed, in the metropolis, as already stated, no person, no matter how indigent, can claim a bed when suffering from such disease for isolation purposes, or, to tell the whole tale, even for the purpose of receiving medical relief. There is but one Municipal Council—that of the city of Melbourne—that is possessed of a disinfecting oven. There is, too, but one ambulance in the Colony for the conveying of an infectious person from one place to another. Even the discharges of typhoid patients are, in not a few districts, still undealt with, or inadequately dealt with; but we understand that this, as far as the metropolis is concerned, is now rectified. Speaking generally, the preparations for dealing with communicable diseases are very defective, and those for properly dealing with infectious diseases are for most parts of the Colony practically non-existent."

The state of matters here described is, I regret to say, not one of which the colony of Victoria has a monopoly. Her case is the more striking, seeing she has had fairly advanced legislation for at least five years when the report was written. Several of the colonies have not reached her standpoint in legislation, or, if so, then only of late. Surely, if practical experience in the working of an Act is any guarantee of its real efficiency, these words are simply condemnatory. They at once suggest the question,—Should local authorities be entrusted with the administration of a branch of the Public Health Act they so signally fail to put into effect? It would seem that the law may be as perfect as the Mosaic economy, but it is no warranty of its success. There is such a thing evidently

as failure, not because the tenor or aim of the law is defective, but because the State looks for intelligence, sympathy, and action in those to whom it has committed certain powers and duties, while neither of them is forthcoming, nor, if experience is any assurance on the point, likely to be. It may not, after all, be reasonable to charge the defect solely to the local authorities. Too much may be expected of them. The Act may ask for more than the human nature of local authorities possesses, and the result may consequently be due to a lack of a wise discrimination in the construction of the Act, more than to any other cause. It is in fact a political blunder which sacrifices efficiency to a political theory of local self-government—a theory applicable to many public functions, but strikingly inapplicable, from the very nature of the case, to this portion of the Public Health Administration.

The conviction forces itself upon my intelligence that a more reasonable division of public health work must be drawn between the central and the local authorities in the immediate future of health legislation. No doubt this would be more easily achieved were not the question of public expenditure so prominent a feature in such a re-arrangement; but the State has already found its way to defray from the Public Treasury the expenses of public departments, such as education, because efficiency is reckoned of more account than local self-government. Other departments might be instanced on the same grounds; but none of them, not even education, occupy the same important rank in the general weal as the conservation of the public health. If the sentiment, "*Salus populi suprema lex*," is to be more than a pretty euphony, then expenditure must be encountered in the exposition of health laws. The ills that infectious or communicable diseases inflict upon our Australian communities are too numerous and too far-reaching to allow for ever the cost of their suppression to be a barrier to entering upon the crusade to which scientific hygiene now invites us.

The administration of infectious diseases comprises notification, isolation, disinfection, inspection, the establishment of bacteriological laboratories, and the control of vaccination and quarantine. Compulsory notification is already incorporated in the majority of our Public Health Acts. It has not been carried out. It is the starting point of a system, and where succeeding parts of the system are studiously left alone it is seen that little good can arise from its its enforcement. This is only partially true. Whichever authority, however, holds in its hands the control of infectious disease, the same authority should carry notification into effect.

Isolation and disinfection must be regarded as the main working parts of the system. Isolation is adopted with the object of

preventing every case from becoming a new and active centre for the diffusion of the disease, and disinfection, in seeking to destroy the microbic life in the patient's discharges, clothes, and premises occupied by him, affords in the same way a barrier to the spread of infection. It is quite true that all cases of an infectious or communicable nature need not be made subject to isolation; the natural history of the microbe will determine this point. The real issue is that isolation and disinfection, when required, should be efficient; but this efficiency can only be secured by the adoption of arrangements for the reception of infectious cases as such, and by the organisation of a corps of men, practised in the work of disinfection, and ready at all times to carry out promptly the duties of their office. It is self-evident that few local authorities can or would respond to this demand, and, consequently, we find, as a matter of fact, that neither isolation nor disinfection on a public scale has been attempted.

I have already commented upon the important position bacteriological laboratories sustain in any system of public hygiene. From their achievements has come all the knowledge that is now seeking to bring about a more intelligent and effective management of infectious diseases; and it is most encouraging to find that the Governments of New South Wales and Victoria have each recently either organised a laboratory or affiliated an existing one. The Children's Hospital in South Australia has for at least two and a half years, under the spirited direction of an honorary officer, Dr. Borthwick, maintained its own laboratory, and has already done excellent work for the medical profession and the public. Only the poverty of the Public Treasury, so it is said, prevents the Government of South Australia from assisting in the maintenance of this well-equipped laboratory. In each case the several Governments recognise their own responsibility in providing this important adjunct to the Department of Public Health.

The inspection of food supplies for human consumption has been legislated for in each of the colonies of New South Wales, Victoria, and South Australia. The most lamentable ineffectiveness, however, characterises the work of inspection, and every other aspect of the public administration of communicable diseases. It is said that even England is twenty years behind several continental countries in this respect; but, if so, Australia is twenty years behind that again. So feebly is the law carried into effect that Central or State Boards of Health, as well as Parliamentary Select Committees, have declared that this important duty should be performed by the State. After five years' experience (1890-1895) of their otherwise admirable Act, the Victorian Board expresses its views in these terms:—"Dangers also of a most serious nature are incurred as a result of want of

veterinary inspection of animals supplying the milk, and of the general want of medical and veterinary inspection of carcases for food. So unsatisfactory indeed is the condition of the milk supply, and so small the part taken by many Councils—that is, local authorities—in supervising it, that we feel the question to be one demanding careful consideration whether we should not ourselves do the work in districts where Councils hold aloof; and as concerns the meat supply, we would invite your attention to the view we have several times expressed, viz., that for all communities of (say) 3,000 persons or more, the sale of meat for human consumption which has not undergone medical or veterinary inspection should be prohibited."

A Select Parliamentary Committee sat in New South Wales somewhere about twelve months ago, and elicited a considerable amount of important evidence on the matter of inspection in connection with abattoirs. This Committee reported that "the present system is far from satisfactory," "that expert inspectors should be appointed," and "that the Government might even work abattoirs in the public interest." The Committee justified this suggestion by saying: "This suggestion embodies an innovation; but the importance of the matter to the general public would more than justify such a departure from the ordinary functions of Government,"

The suggestion of this Select Committee goes beyond the advocacy of inspection merely. It all the more emphasises the necessity for efficient inspection at the hands of a State authority. If nothing short of working the abattoirs by the Government would meet the case, it the more strikingly demonstrates the present deplorable condition of things. So far as the other colonies are concerned, I have yet to learn that anything better can be reported. Even the supervision of milk supplies, simple as it may seem, is not attempted with any more efficiency than the inspection of meat; yet for years past Central Boards of Health, and professional and lay sanitarians, have times out of number made earnest appeals to the public, setting out the urgency of effective inspection on all food supplies. But they have in most of the colonies cried in vain, arousing no response but the sound of their own voices.

New South Wales has had a Dairies' Supervision Act upon its Statute Book for sixteen years, and yet the report of the State Board of Health is—"That a large number of prosecutions have been instituted by the Sydney Council against dairymen selling adulterated milk. The police also in a few districts have taken proceedings against persons who were not registered." "There are, however," it continues, "numerous cases where premises are in an insanitary condition, or where other breaches of the Act are committed, and offenders are not punished, as they should be, by

having their registration cancelled, or by other proceedings being instituted." The Report further states that "it is certain that the proportion of dairy stock suffering from this disease (viz., tuberculosis) is much smaller than in European countries. There are yet the strongest reasons for stamping out the cases that are discovered, not only to arrest the spread of the disease among the cattle, but also because of the serious risk of the tuberculous matter contained in the milk causing consumption of the lungs in the human beings who use it."

The secret of failure is pre-eminently apparent. Only a few weeks ago, and since writing the foregoing, Dr. Gresswell, the eminent Chairman of the Victorian State Health Board, publicly stated that reforms were seriously demanded. They must necessarily be slow, he said, more especially where administration was local and not central. "Legislation," he further said, "was being prepared in Victoria which he hoped would go far towards remedying most of the evils which so tenaciously clung to our meat and milk supplies." This expression of views comes as a hopeful forecast; but unless the lines of the legislation suggested are different from the legislation of to-day, the same disappointing tale of failure will have again to be told. I can add no word to what has been repeatedly urged upon the public with the object of arresting their attention to the scourge of consumption. I will not indulge in dragging before you a series of figures to show that in every colony it stands first upon the list of fatal diseases. The time was when the medical art stood hopelessly by, and, in common with mankind generally, deplored its ravages; but the time is changed, and encouragement comes from many quarters that the time is not far off when its power will be broken, and its course rendered as amenable to control as the course of typhus fever or small-pox has now become. (Dr.) Sir Thorne Thorne's words at the Guildhall banquet in June last are worthy of repetition:—"When the Queen ascended the throne, consumption was a terrible disease in this land; the deaths from consumption were one-quarter of the whole mortality of the country. Every year the Queen lost 50,000 of her subjects by deaths from consumption, and for a long time we did not know it was a preventable disease—as preventable as typhus or any other disease which arises from fever; and, now that we know that, we are beginning to get control over it, and the reduction is going on, I am glad to say, very rapidly. When the Queen came to the throne, from 400 to 500 persons died out of every 100,000 of the population from consumption. Well, we have reduced it now to 140 per 100,000. That is a great deal too much still, but it is a very great reduction. It is a very satisfactory reduction, but the death-rate is still far too high; and, now that we know the condition in which consumption, like typhus, is a preventable disease

and have ceased to believe that hereditary weakness is the cause of it, it will very rapidly go down; and we may—not perhaps in my old age, but in the old age of a great many of the persons I have the pleasure to see before me—I say that we may find that consumption will be as rare a disease in this country as typhus has become at the present time."

These are words of great encouragement. If, however, a consummation so desirable is to be achieved, intelligent and ceaseless efforts must be directed by improved legislation. The tubercle bacillus is highly infectious, and the avenues by which it can reach the human subject are more numerous than in any other communicable disease. A person suffering from it may infect other persons; animals supplying milk, or whose carcases are utilised as human food, are sources of infection; and a whole series of domestic animals with which men and women are constantly in contact, although differing in degree, are mediums of its conveyance to man. The horse, the cow, cattle generally, sheep, swine, dogs, cats, and birds, die of tuberculosis. Surely, therefore, the keenest vigilance is wanted, backed by the most advanced form of public health administration, to oppose a disease at once so subtle and so destructive.

I foresee that my remarks here will at once be discounted by the statement that Australia is freer from tuberculosis than old European countries. This notion, I admit, is countenanced by health reports occasionally saying that "the proportion of dairy stock suffering from tuberculosis is much smaller than in European countries." In the face of a system of inspection so utterly ineffective as the present is admitted to be, this assertion cannot be relied upon. A few years ago the same misconception was held respecting the condition of things in England, but it does not exist to-day. Recent experience has dispelled the illusion, and has shown that as inspection became more efficient so the proportion of diseased cattle was found to increase. One authority asserts that "the proportion of infected cattle has been found to rise much higher, one-half—even three-fourths—of the cows being affected." While, as regards the carcases for human food, he says: "Where inspection is efficient, the existence of tuberculosis is revealed in from one to three out of every ten head of cattle slaughtered in the abattoir." What efficient inspection has done for England it would do for us. For an Australian veterinary surgeon, Mr. S. S. Cameron, of Melbourne, tells us—in an interesting communication read before this Association a few years ago—speaking of tuberculosis: "I have, however, no hesitation in saying that it is as common in these colonies as in any part of the world." He proceeds to defend his position by arguments and illustrations which it would take too much time to detail. I am disposed, however, from the nature of the disease and the

arguments with which he supports his opinion, to accept his conclusion. If his view approaches the truth, then we must be living in a Fool's Paradise, and falling very far short of the protection which ought to be afforded to the public against so dreadful a disease. Germany, Belgium, Sweden, and some of the States in North America, are said to be twenty years ahead of England in respect of the inspection of meat; so when our legislators once more turn their attention to this question, ample and practical experience is available for guidance in these countries.

My remarks would be incomplete without some reference to small-pox, one of the most infectious of all communicable diseases. Nothing seems to me to indicate more strikingly that we lag, in public health matters, behind the age than the attitude which several colonies maintain towards compulsory vaccination. The fact that the large populations of New South Wales and Queensland are practically unvaccinated communities is a matter for surprise and misgiving. The protective power of vaccination is now as well-established as any fact in any of the most rigid of the inductive sciences. Barring the dread that disease may be conveyed by the use of humanised vaccine lymph, and as the ground for such fear is now extinguished by the substitution of sterilised calf lymph, no objection remains to the compulsory enforcement of vaccination. Speaking as one who has seen the ravages of small-pox among the unvaccinated, no man—legislator or private citizen—if he has ever witnessed the terrible spectacle which so many of these persons under small-pox present, can be anything but a supporter of compulsory vaccination. Having suffered an attack of small-pox at the age of 20, I took special advantage of my immunity, as a student, to see all that could be seen and learned respecting this disease in a large city hospital, from which it was then never absent. No ordinary disease presents such shocking features; and, certainly, legislators do not realise their weighty responsibilities to the people when they continue indifferent to the disastrous contingency of an invasion of this very horrible disease. Quarantine is, and has been, serviceable; but it is no unusual thing to hear the remark made, even by chairmen of Public Health Boards, that we are bound, some day, to witness its appearance in Australia. When it does come, and gets beyond quarantine control, then pity will be felt for the unvaccinated.

A parade of statistics seems to me to be unnecessary in pressing the urgency for effective vaccination. I may be allowed to summarise the position which it holds to-day in the following manner:—

(*a.*) Indisputable evidence is in hand to show that the mortality from small-pox, where vaccination has been practised, has been reduced 72 per cent.

(*b.*) In no other disease has an abatement of the death-rate from any cause, sanitary or otherwise, taken place to anything like the same extent.

(*c.*) Its mode of action is no longer mysterious or supposed to be contrary to Nature, but is shown by the light which bacteriology and experiment has thrown upon it to be one of several illustrations of a principle in Nature by which immunity from certain diseases is secured.

(*d.*) Prior to the introduction of vaccination, small-pox was the scourge of infant and adolescent life; in vaccinated communities to-day it is the adults who chiefly suffer from it.

(*e*) It has been clearly proved by experiment that revaccination at a given age of 15 or 16 years, restores the protection to adults.

(*f*) Even when adults who have been vaccinated in infancy, and who have not been re-vaccinated, are attacked by small pox, the disease runs a highly modified course. (This was my own experience at the age of 20.)

(*g*) The consensus of opinion with respect to the use of humanised or calf lymph, is, that humanised lymph should be abandoned in favour of calf lymph.

This, then, is the position of the vaccination question. For the security of the colonies, the law throughout Australia should be assimilated on a compulsory basis. For this, I presume, we must wait the awakening of the legislatures that still lag behind.

I will not essay to weary you further. The contention is sustained that the essential weakness in Australian public health administration is the control of communicable diseases. Our death-rate in some of these diseases is even higher (see diagrams) than the death-rate of England, notwithstanding the favourable character of many of our conditions and surroundings. For instance, we are young communities, with preponderating proportions of youthful population. We inhabit a new soil, with spaces for air and settlement unknown in the old countries of Europe, while our climate must be said to be conducive to longevity. There is great need for amendment in the control of these active diseases. We undoubtedly make the mistake of following England in her efforts to establish a complete system of local self-government. I am not opposed to local self-government as a working principle, but I none the less regard the inclusion of the administration of infectious diseases, as outside its sphere. The light which science has thrown upon public hygiene is comparatively recent; the principle of local self-government in England is very

old. Yet in England, recently, departures have had to be made from the principle, especially in matters of public health. Local self-government covers many things in the management of the common affairs of a community ; but it has been clearly shown that it utterly fails to bring about, in local authorities in Australia, an appreciation of the objects legislation seeks to secure in the control of communicable disease.

The State must assume this responsibility. It alone possesses the means of organising the necessary skill, experience, and aptitude required to meet all the contingencies arising in the course of an outbreak of infectious diseases among the public, and further, of enforcing the law. The sooner the position is taken, so much the sooner will the public see and appreciate the great work that is being done for them ; so soon, too, will the local health authorities realise that they are not called upon to undertake responsibilities which many of them have declared to be outside their functions. They will come to feel, under such new conditions, that the branches of the public health administration are equitably divided between the State and themselves, and in this conviction will the more heartily fulfil the duties appointed to them. In mutual co-operation the two authorities will work together, and will doubtless succeed in bringing about a condition of the public health, of which every sanitarian will be proud.

For the starting point of all this, we must rely upon the intelligence, the patriotism, and earnestness of our legislators. I appeal for a comprehensive consideration of this question, realising that if they once see its urgency, and become roused to the sense of deep responsibility that lies with them, to introduce better and more effective legislation, it will speedily come about ; and once accomplished, no service to their country will bring them greater satisfaction, and no labour they could give will reap for the community a handsomer or more permanent reward.

One word further. Shortly after this address was written, my attention was directed to an address delivered at the British Medical Congress in Montreal, by Dr. Hermann Biggs, of New York. I was delighted beyond measure to find that the views expressed in the address now delivered to you had found practical and striking embodiment in the hygienic and sanitary management of that great city of two-and-half million inhabitants. Dr. Biggs' address is an able defence of the position.

No. 1.—ON THE HISTORY AND PREVALENCE OF LEPRA IN AUSTRALIA.

By J. Ashburton Thompson, M.D., D.P.H., Chief Medical Officer of the Government, and President of the Board of Health, of New South Wales; Examiner in Hygiene at the University of Sydney; Fellow of the Royal Institute of Public Health. Honorary Fellow of the Incorporated Society of Medical Officers of Health.

(*Read Friday, January* 7, 1898.)

[The following paper contains a summary of the more important parts of "A Contribution to the History of Leprosy in Australia." which was written in 1894, and published by the National Leprosy Fund in the middle of 1897; to which reference must be made for the detailed evidence on which the statements recapitulated in it rest.]

Australia had been often sighted by navigators before Captain Cook landed and took possession on behalf of the English Government in 1770; but the first foreign settlement in the country was effected by an expedition which numbered about 1,030 souls, at Botany Bay, near Sydney, in 1788. The whole continent had, it is believed, been free from intrusion in every part down to that date, with the following possible exceptions: In 1837–9 Sir George Grey, Governor of South Australia, discovered some rock-drawings which were judged to be of other than aboriginal execution, at a point near the north-western coast line; and on the north coast, Flinders, issuing from the Gulf of Carpentaria, encountered a fleet of Malay prahus engaged in tripang fishing, and was told by its leader that he was the first Malay to reach that coast about twenty years before, or about 1783–4. For many years, at all events, the aboriginals at this part remained at enmity with their Malay visitors, who returned year by year, and, according to the available accounts, did not penetrate further than the beaches, where they usually had to fight for the wood and water they went to secure.

At discovery by the whites the country was found parcelled out among many different small tribes, and it is considered that the state of the people must have been what it was found to be in 1788 for several hundred years before. No information as to absolute numbers of the nomad autochthonous population at any part of the country is available for older years, and no trustworthy information is available for later times.

Sydney was the original seat of Government for the continent, and for many years was consequently the repository for all archives touching Australia and Tasmania—Tasmania being usually reckoned a part of Australia, from which it begun to be separated by the rather narrow Bass Strait only during Tertiary times. The collection of books touching this country in the Public Library at Sydney numbers about 5,000. Gentlemen officially concerned in tabulating and preparing the old official archives for the Press are of opinion that there is no mention of leprosy down to the year 1836 at all events, nor of any disease under which lepra might be supposed to lie hid; on the other hand, information as to all diseases down to that date, and for long afterwards, is extremely meagre. The works of several explorers of note which deal with wide tracts of country on different parts of the continent, and which were written from about 1830 onwards, contain no reference to anything resembling lepra among the autochthons, with a single exception; and in that case there is nothing to show that the word "leprosy" was not used in its banal sense, the writer, who was not a medical man, probably intending merely to emphasise the disgusting character of some skin disease. Several explorers of note have informed me that they have never met with any disease among the aboriginals which they suppose might be leprosy; nor, after looking at many photographs of lepers, did they hesitate to adhere to that statement. Among these gentlemen was the late Baron Sir Ferdinand von Mueller, K.C.M.G., M.D., F.R.S., &c., &c., who spoke chiefly of the south-western part of the continent about the year 1847, and of a part of the Northern Territory about 1855. It may be taken, in my opinion, that there is no record of lepra among the primæval autochthons in any part of the continent.

Comprehension of the progress of white settlement will be facilitated if it be remembered that Australia has an area of just 3,000,000 square miles; that the earliest Government at Sydney was the Government of Australia; that distant parts were settled by sea as became possible, and were gradually erected into separate Crown colonies; and that all these Crown colonies (always including Tasmania) were at different dates granted the right of self-government, and thereby became autonomous States. The net result has been that Australia is divided into the following territories, which became self-governing at the dates mentioned; Tasmania, 1854; Western Australia, 1890; South Austra'ia, (with which is the Northern Territory), 1856; Victoria, 1851; New South Wales, 1851; Queensland, 1859. For the first sixty or sixty-five years the population was practically entirely English. In 1851 the discovery of gold led to the immediate influx of large numbers of people who came from almost every country, and from almost every recognised leprosy area in the world to New South Wales

and Victoria. These natives of recognised leprosy-areas were in small proportion to the rest of the population, if the Chinese (of whom further mention will be made below) be excepted, and no occurrence of lepra among them has been recorded. The total population of Australia at the date at which the various territories were granted responsible government was not so much as 500,000; at the present day it is about 4,000,000.

The conditions of life in this country are extremely favourable to health. The earliest settlers no doubt endured similar hardships to those necessarily suffered by explorers in later years, for they were themselves in the position of explorers; but, without going into detail, it is indisputable that the conditions of the population as a whole, and in every territory, has been and still is one of ease. Food, which continued to be of precisely the same kinds as they had been accustomed to in England, was always wholesome and sufficient, even when it was not plentiful. There is no malaria in any of those parts of Australia, which, thus far, have become populous, the exception being the very sparsely inhabited north. Lastly, the climate, speaking generally, is as good as can be imagined; and while the temperature necessarily varies greatly between parallels of south latitude so widely separated as are the 44th and the 11th, it is in every inhabited part such as encourages outdoor habits of life. Nothing at all is traceable in the circumstances of life in Australia such as possibly might have importance in relation to occurrences of lepra.

In 1851, this healthy, small, and widely scattered population was composed in the main of Europeans, and chiefly of English. The aboriginals retired before them, and died apparently almost in proportion to the degree in which they were forced into close contact with the whites; they never were either of importance as enemies, or of use as servants. Besides the aboriginals there was of course among the whites, even at that date, quite a small proportion of persons belonging to the miscellaneous nationalities of which representatives are to be found in every port. There is some statistical evidence that they were, at some points, numerous enough to be separately counted at the censuses, and yet they were in quite inappreciable proportion to the total population; but in the year named the discovery of gold caused an influx of large numbers of Chinese. Towards the end of that decade there were no less than 42,000 of them in Victoria, and in 1861 there were 12,000 in New South Wales. In 1881 the numbers in both of these, the richest and most populous territories of Australia, became about equal, and were about 10,000. Chinese appeared also, though in far less numbers, in all the other territories; but it is not possible to ascertain when they first appeared, and at what rate they increased (at least during earlier

years), for they were seldom distinguished in the census abstracts. Thus, in 1863, both they and members of other coloured races were scarcely known in Tasmania. They were present in noticeable number in 1875. They were first distinguished at the census of 1881, and then numbered 844; and in 1891 had increased to 943. In Western Australia they were first distinguished in 1881 (145), and there were 917 in 1891; but there is no doubt they were present before the first-mentioned date. In South Australia, Chinese were a curiosity in 1860. They were distinguished at the two latest censuses, and then numbered 321 and 288. In Queensland there were some Chinese as early as 1853. "Natives of China and Japan" were enumerated (538) in 1861, increased to 10,000 in 1876 (but they were nearly all Chinese), were separately enumerated in 1881 (11,000), and numbered 8,522 in 1891. Chinese appeared in the Northern Territory in or shortly after 1872. There were 2,722 in 1881, and 3,447 in 1891. Now, in all those territories the danger from imported lepra to the white inhabitants lay with the Chinese, and, with exception of Queensland, with Chinese alone. In Queensland, which is a sugar-growing country, large numbers of kanakas have been introduced from various lepra-infested groups of islands in the South Seas to work on the plantations. They began to arrive in 1863. They increased from 1,543, in 1868, to more than 11,000, in 1881, thereafter decreasing to between 8,000 and 9,000 in 1891. There have never been other than casual, almost it may be said individual, kanakas either in New South Wales or Victoria, and none at all elsewhere. As regards possible importation of lepra, then, it is quite certain that the people of Queensland ran risks both from kanakas and Chinese; but those of New South Wales and Victoria (and the remaining territories) from Chinese alone.

The occupations followed by the Chinese always included cooking, market-gardening, peddling, &c., as well as mining. In earliest years they were almost always employed in the first-mentioned businesses, and in stores. During the middle period the largest proportion of the total were occupied in placer gold-digging. In later years the proportion of miners among them fell, and probably the larger portion present followed one or other of the trades. They have always been perfectly free within the country, and lived and travelled where they liked. They live largely by themselves, at gardens, and in particular quarters of towns and cities, but they mix freely with the whites. The cooks alone, as a rule, are employed in the houses of the whites, and then at hotels and boarding-houses, The relations of the kanakas to the whites are slightly different (in Queensland): they were imported under a contract to work for so many years, at the end of which they were to be returned to their islands, if they chose; but if they preferred to remain they could either re-engage

themselves to work as "free boys" at the plantations, or else could set up in some semi-labouring business. Whichever they did, the free boys were at liberty to travel about the country, and were not infrequently employed as house-servants. In all the territories the Chinese, and in Queensland the kanakas as well, were pretty equally diffused among the whites all over each territory, and were in free occasional or business contact with them.

From this review of the general conditions of life, it is necessary to turn to the recorded occurrences of lepra. Before doing this it should be noticed that an epidemiological study of the present kind can be made only if two conditions are first fulfilled : one is, that the information at command shall be complete enough to furnish a true outline (at least) of the course followed by the disease among the people which is the subject of study ; the other, that there shall be reasonably good evidence that the patients reported to have suffered in former years from the disease under examination really presented cases of that disease. In the present instance it is my opinion that the first condition has been fulfilled ; the second has probably been sufficiently well fulfilled, but with this exception : that while it is plain enough (from published accounts, photographs, and in one case proficiency in the observer, within my own knowledge of him, &c.) that the cases of lepra alleged to have occurred were cases of lepra in reality, it is, on the other hand, almost certain that many additional cases have either escaped recognition altogether, or else were never put on record. Here, also, it seems proper to point out that while the diagnosis of lepra only occasionally presents difficulties which cannot be resolved by an attentive student who has enjoyed sufficient opportunities of making himself familiar with the varied clinical aspects under which the disease shows itself, yet it is notorious that persons who in other respects are highly competent, but who have not had the opportunities referred to, very often indeed overlook or misapprehend examples of the disease whose identification presents in reality no difficulty at all, and even deny or dispute that they are cases of lepra when that explanation of them is suggested. It is most important to remember this, and it should be specially borne in mind when the negative statements of travellers, both medical and lay, are under consideration. The assertion of a known proficient that he met with no cases during his exploratory travels is good, as far as it goes at all events ; a similar statement from one of whose proficiency there is no evidence is worth nothing at all.

As regards lepra among the Australians, it is necessary to divide them into primæval autochthons unaffected by immigration, and those affected by immigration, who may be called aboriginals for the sake of distinction. Concerning the primæval autochthons

there is nothing but negative evidence; lepra has never been observed among them. Nevertheless, the Australian is susceptible of lepra, and it has been seen among aboriginals. In 1892 an aboriginal full-blood male, was recorded at Maryborough, Queensland (S. Lat., 25° E. : Long., 154°). He roamed over the country, in the neighbourhood of the town named, with the remnants of his tribe. There are sugar plantations there, and for many years there have been kanakas at work upon them. No other aboriginal leper was discovered there. There is positive information that one kanaka leper (only) has been seen there. It must be said here that the information available regarding every part of Queensland is extremely meagre. The nature of the illness suffered by the kanaka was not recognised by the gentleman who reported it, but was easily identified by the photographs he appended to his account of the case; and it is quite certain (from the number of kanakas who have been employed there during a long term of years) that many cases must have occurred which have remained unrecognised. In 1894 an aboriginal suffering from leprosy was received at the lazaret at Port Darwin (about S. Lat. 13°, E. Long. 132°), his disease being then first diagnosed. I discovered, after some search, that he was known (by a layman) to have been ill since 1879. After further inquiry I satisfied myself that the Government Resident on the MacArthur River, N. T. (about S. Lat. 16°, E. Long. 137°), which debouches on the west side of the Gulf of Carpentaria, had observed cases of leprosy among aboriginals in that neighbourhood during years immediately following 1888. Two cases were mentioned—those of a man and a woman (the latter being the only case of a female aboriginal thus far brought to light), but it was not stated that those were all which had been seen. From the letters of still other lay correspondents it became apparent that lepra had been observed among aboriginals inhabiting the country watered by the Alligator Rivers, N.T. (about S. Lat. 13° to 15° and E. Long. 132° to 134°); probably their number was considerable. Early in 1895, a male aboriginal was taken into Port Darwin from the Alligator country, and his case was identified by the Government Medical Officer in charge there as being one of *L. nervorum*; thus the lay accounts—in themselves scarcely mistakable—were to some extent corroborated by medical opinion. Noteworthy points in this connection are the very late date at which the first case of lepra in an aboriginal was noted—namely, in 1892; and while it seems likely that lepra must have existed among the aboriginals at several points of the Northern Territory (which, by the way, has an area of nearly half a million square miles) for a good many years, yet it would be presuming a little too far to take it that it occurred among them while one or other tribe of them might be regarded as in their primæval state. On the other hand, if imported to

them, it must have been by one of two races: either by the Malays—a contingency which, under all the known circumstances, seems to me at least remote—or by the Chinese at some date later than 1872. Here the vast extent of the area over which the infected tribes extend must be remembered, and that while these tribes were not in contact with any town, the Chinese, on the other hand, spread only over those comparatively small areas on which employment or gold could be found in conditions (of neighbourhood to whites) which would make their prolonged stay profitable. Were it granted that they might have been infected by the Chinese, still it is difficult to see how the opportunity for communication came about. Lastly, there is nothing of an evidential nature to warrant connection of their infection rather with the Chinese in recent years than with the Malays in older times, or *vice versâ.*

The question whether lepra was indigenous to any part of Australia is so important that it has seemed necessary to go into some detail in speaking of occurrences of the disease among the aboriginals; but it remains unanswered for the present, in my opinion; yet, as the foregoing information is at this date entirely new, it is possible that more light may be thrown upon it as time goes on and attention is more steadily directed to it. This branch of the subject, then, must now be left aside, and the incidence of lepra on the whites and on foreign immigrants must be examined.

I go on to speak of other parts of Australia, and of leprosy among native-born whites, immigrant whites, and coloured aliens. No cases have ever been observed in Tasmania or in South Australia. Only two, both in Chinese, have been observed in Western Australia. There have been many recorded cases both in whites and coloured aliens (Chinese and Kanakas) in Queensland; but the list is, beyond doubt, remarkably short of the fact as regards the latter. It is probably deficient there as regards the whites, too—to what extent cannot be guessed; and that it is deficient is but an inference from the known facts, though a very strong one. Remain, therefore, New South Wales and Victoria, for which territories the information, though doubtless incomplete, is yet in all probability sufficiently full for practical purposes. The epidemiology of lepra in these two territories presents a problem of great interest.*

* Although I shall probably not have occasion in this account to refer again to Queensland, it is nevertheless sufficiently interesting to be noted that the first case of leprosy in Australia of which there is evidence was encountered there, the late Dr. Bancroft having discovered the history of the illness of an aged Chinese in old case-books of Brisbane Hospital. Though the nature of the case was not recognised at the time (1855), the description was to his mind (and after reading the original M.S. is to my own) sufficiently clear. The first case of lepra in a white native of which there is record was observed and identified by myself, the patient still surviving (see Annual Report on Leprosy, Board of Health, New South Wales, 1895, Case L), and presenting an example of healed *L. nervorum* with consecutive neurotrophic changes. The date of attack was 1856.

The epidemiology of the disease in New South Wales may be summarised as follows :—Between 1856, when the first case in a white occurred, and 1882, no less than 15 cases in whites are known to have been met with, the dates of attack being ascribed to eleven of the years in that series of twenty-seven years; and during that term only one West Indian, who was observed (under confinement in a lunatic asylum) suffering from *L. nervorum*, and one Chinese, a patient in a general hospital, also affected with *L. nervorum*, were noted, in 1859 and 1861 respectively, among immigrants from leprosy-areas. During the years from 1882 to the present date many cases in coloured immigrants and in whites were recorded, as shown in the Table; so that during those twenty-seven years a good many cases were observed in whites, and in coloured immigrants only two cases.

In Victoria, the course of events was exactly contrary. From 1858 (and apparently from two or three years earlier) the presence of Chinese lepers was known and officially recorded. Their number nevertheless, remains doubtful. It is certain there were several in 1858 ; thirteen were recorded at a date subsequent to 1863 ; thirty-one were enumerated in 1866 ; and, from the records, it is apparent that there were always several Chinese lepers scattered over the territory down to 1889. Between 1863 and 1867 a white leper was noted ; but he had lived ten years in India, and it was clearly stated he had acquired his disease there. No other white case was observed until 1884 (attacked in 1879), and this patient was a native of New South Wales who had lived in Sydney, where he was born, from 1859 to 1867, and then in New Zealand (an old leprosy-area) until 1874, when he arrived in Victoria. A third case was observed in a white in 1891. He had been born in India, and until his arrival in Victoria in 1885 had been a sailor trading in the East. He was attacked in 1889. So that while many cases in Chinese have been observed and recorded in Victoria between 1858 and the present date, there never has been noted any case in a native Victorian, nor any in whites but such as were (as to two of them), or may have been (as to the third), imported after acquiring the disease.

Secondly, it is to be observed that during nearly all the years dealt with, lepers were in both these territories entirely free and unrestrained, whether they were white or coloured. In New South Wales some provision was made for isolation of a few coloured lepers who had become helpless and destitute, and who were therefore isolated voluntarily in a sense, in 1883. During the following years one or two others were isolated under indirect pressure, as well as some more who came in as being helpless ; but it was not until 1890 that by Act of Parliament the forcible detention of those already in captivity was made legal, and the reporting and detention of all cases which might be detected for the future was made compulsory both on medical men and on the

laity ; and in this respect of isolation the course taken was almost the same in Victoria. Somewhat before 1888 there were two or three helpless lepers isolated voluntarily, and in that year it was made legal to remove to a lazaret and to detain there any newly-discovered leper ; but this could be done only if two medical men certified and reported—that is, if two physiciaus chose to take that course, then the central authority might (again if they chose) forcibly remove the leper so reported ; but no compulsion to report, or to isolate, lepers was laid on anyone. It was not until 1893 that notification and isolation of all cases of lepra was made compulsory in Victoria.

I repeat, then, that it is clear beyond all doubt that there were many foreign lepers in Victoria, from 1858 onwards, and that they were entirely uncontrolled ; but no native white leper was ever recorded or detected according to the result of very extensive inquiries made, not only in official quarters, but of individual medical men still surviving and practising from the earliest date mentioned. On the other hand, it is equally clear that from about the same time there were a good many white lepers in New South Wales, long before any important number of cases among Chinese or other immigrants had been observed ; and more than this, the disease died down—almost died out—in Victoria before notification became compulsory. So that, on the whole, it may well be said that if lepra can be diffused by lepers, then it seems as though there were something about Victoria which prevented the imported infection from "taking" there. Thus the most that can be suggested by way of adverse comment on these statements is, that cases probably did occur among Chinese, &c., in New South Wales during the long series of years before 1883, although they were not observed, recognised, or noted, the fact appearing in any case to be that the infection did take in New South Wales, but refused to take in Victoria, on the white inhabitants.

There are a few other points which must be noted here. They are, first, that there has never been any such prevalence of leprosy among the Chinese in either territory as might fairly be expected of a communicable disease occurring among a people who habitually live at extremely close quarters with each other (and who, according to my observation, show no particular fear of that disease) ; secondly, that most of the native-born white lepers in New South Wales have not merely never associated with coloured people of any race, but have certainly never been in conscious contact with any leper. The number of Chinese in Victoria was vastly in excess of the number in New South Wales down to 1881. The total population of the two territories, which march together, was at every date practically equal ; but the area of Victoria being 88,000 square miles, and that of New

South Wales being above 310,000, conditions attaching to density would seem to be in favour of spread in Victoria; there is a difference of 5 degrees in the mean annual temperature; and lastly, there are no other differences (political or social) between the two.

I point out that the remarkable features of the case thus briefly described exist only inasfar as the evidence from which they have been drawn is adequate to establish them as facts; and that for that evidence, which is necessarily lengthy, reference must be made to the writing which was mentioned at first, and which concludes with the two following statements of opinion:—

"I. Although lepers were imported to Victoria steadily during a long term of years, and in considerable number, and although they always remained entirely unrestricted in their movements among the whites, no Victorian native white who had never left the Colony has ever been attacked. Moreover the disease died away in Victoria quite independently of restrictive measures against the liberty of lepers, which in fact were first taken only in March, 1893.

"II. Although coloured aliens of many different races, all of which have furnished cases of leprosy in Australia, have been imported during many years, and in large numbers, to all the better populated parts of the country, which extend along the coast-line from about the 146th degree of east longitude, easterly and then northerly towards Cape York (Victoria, New South Wales, Queensland); and although native whites who have never left their colony have been attacked at various places in New South Wales and Queensland; there is no evidence, and no good reason for surmising, that any such native white has been attacked who lived south of the 35th parallel of south latitude (part of New South Wales and Victoria)."

[*See table on next page.*]

Table showing the years in which Lepers were observed in five Colonies of Australia, their Race, and Number; and in which Legislation against the liberty of Lepers came into operation.

	Western Australia.	Victoria.	New South Wales.	Queensland.	Northern Territory.
1855	......	......	......	1 Chinese	......
1856	......	......	1 white (observed 1895)	......	......
1857	......	......	......	1 white	......
1858	......	Some Chinese	......	......	......
1859	......	......	1 coloured West Indian	......	......
1861	......	......	1 Chinese	......	......
1863 to 1867	......	1 white (imported ill from India). 13 Chinese were enumerated.	......	......	......
1868	......	......	1 white	1 white. (From this date onwards, many kanakas.)	......
1869	......	......	1 white	......	......
1870	......	......	1 white	......	......
1871	......	......	2 whites	......	......
1872	......	......	2 whites	......	......
1873	......	15 Chinese were enumerated.	1 white	......	......
1875	......	......	1 white	......	......
1876	......	......	......	1 Chinese	......
1878	......	9 Chinese enumerated at Ballarat.	1 white (observed 1895)	1 Chinese	......
1879	......	1 white	2 whites	3 whites (about this date).	......
1881	......	......	2 whites	1 Chinese	......
1882	......	......	1 white	7 Chinese (or were discovered between this date and 1889).	1 Chinese.
1883	......	......	1 white, 5 Chinese	......	......
1884	......	......	2 Chinese, 1 white	......	5 Chinese (since 1882).

1885	....	2 Chinese (additional ?)	1 white, 1 Chinese, 1 coloured West Indian.	1 Chinese	*Legislation*—Report of recognised cases made compulsory.
1886	....	....	2 Chinese, 1 Javanese..	....	....
1887	....	1 Chinese (additional ?)	1 Chinese	....	....
1888	1 Chinese	1 Chinese (additional). Permissive legislation.	1 white, 3 Chinese	4 Chinese	1 white.
1889	1 Chinese .... *Legislation* — Report of recognised cases made compulsory.	3 Chinese, 1 white	1 white, 1 Chinese	2 Chinese, 1 kanaka, 1 Cingalese.	10 Chinese (about, observed since end of 1884).
1890	....	....	2 whites .... *Legislation*—Report of recognised cases made compulsory.	1 white, 1 Chinese, 1 kanaka.	....
1891	....	....	5 whites, 5 Chinese, 1 kanaka.	1 white, 1 Chinese .. ... *Legislation*—Report of recognised or suspected cases made compulsory.	....
1892	....	....	4 whites, 8 Chinese ..	1 Chinese, 1 Cingalese, 1 Malabar, 4 kanakas, 2 aboriginals.	....
1893	....	2 Chinese .... *Legislation*—Report of recognised cases made compulsory.	4 whites, 2 Chinese, 1 Madrassee.	1 white, 1 kanaka, some aboriginals.	....
1894	....	....	3 whites, 1 New Caledonian, 1 Punjaubi.	2 whites, 1 Cingalese, 3 kanakas.	1 Chinese, 1 aboriginal.
1895	....	1 Chinese	5 whites	Since 1894, several cases have come to light, including two or three in native whites.	1 aboriginal.
1896	....	....	3 Chinese	....	....
1897	....	....	1 white	....	....

No. 2.—SHORT DESCRIPTION OF A NEW METHOD OF PREPARING AND PRESERVING ANATOMICAL AND PATHOLOGICAL TISSUES, WITH SPECIAL REFERENCE TO THEIR COLOUR-PRESERVATION.

By SYDNEY JAMIESON, M.B., Edin., M.R.C.S., Eng.

(*Read Friday, January*, 7, 1898.)

[*Abstract.*]

NOTHING can possibly add more to the utility of museum preparations, especially for purposes of teaching, than a method of preserving the natural colour of organs and tissues permanently.

Hitherto it has been the custom to remove, as far as possible, the blood from the parts while fresh, and straightway preserve them in various strengths of alcohol.

For some tissues this is all that is required, as the distinguishing features may thus be retained sufficiently well for purposes of demonstration.

For instance, a valvular lesion of the heart, or a congenital malformation of an organ may, by this means, be preserved indefinitely, and still retain its distinctive freshness more or less unimpaired.

Far otherwise, however, is it with the majority of pathological conditions.

In many cases, within a comparatively short period of time, the appearance of the parts becomes so much altered that it ceases in any way to convey to the eye those characters by which the diseased process may be recognised.

So much so is this the case, that until quite recently one would search in vain the shelves of a pathological museum for an adequate representation of so common and characteristic a condition as chronic venous congestion of the liver.

By the use of a formula, the details of which I will now describe, it has now become possible to preserve such specimens in a condition almost identical with that which they had when first removed from the body.

Organs, however, preserved in this way, still require a certain amount of care, in order that their natural colouring may be entirely retained.

Exposure to direct sunlight for a lengthened period will in many cases remove, to some extent, the colour.

It therefore becomes necessary to keep such preparations in a semi-dark atmosphere, except when being used for purposes of demonstration.

The following is briefly the method of procedure :—

Before subjecting the tissues to the preserving fluid, it is necessary to avoid, as far as possible, any contact with water; and so, instead of washing them in water as was done formerly, they are merely wiped dry with a piece of cloth.

They should then be placed immediately in a solution consisting of—

> Commercial Formalin, parts 5-10 (40 per cent. Formic aldehyd.) ; Chloride of Soda, part 1 ; Sulphate of Soda and Sulphate of Mag. in equal proportions, parts 2.

made up with water to 100 parts.

The length of time during which they should be subjected to this fluid varies with the size, thickness, and consistence of the tissue.

Objects of the size of spleen and kidneys (normal) require about two days, and the fluid should be changed twice during that time.

Large objects require a longer subjection to the fluid, the time varying directly with the size and thickness of the organ.

The fluid, during the process, becomes of a dirty brownish-red colour ; when this is seen fresh fluid is required.

It is particularly necessary that all parts of the tissue should be brought into contact with the fluid, and that the object should be given the shape and position which it is desired that it should retain permanently.

While in the solution the organs change colour, and assume a dirty bluish-grey appearance.

This colour is, however, discharged on placing them in 95 per cent. alcohol, and the normal colour returns.

Before placing them into alcohol they should be washed thoroughly in alcohol until the latter no longer becomes cloudy.

It must on no account come into contact with water.

It should be left in alcohol for a period sufficiently long for the normal colour to return, and no longer.

If left too long in this fluid the colour is removed.

As soon as the colour has completely returned, it is placed in the permanent mounting fluid, and for this purpose we find that the best solution consists of equal parts of glycerine and water.

In this fluid the material at first floats, but as soon as it becomes thoroughly impregnated it will sink to the bottom.

After a short time the mounting fluid begins to assume a yellowish colour. It should then be changed and fresh fluid substituted.

It is now permanently prepared and ready for exhibition; but it must be remembered that as far as possible it should not be exposed for a lengthened period to direct sunlight.

We find, so far as we have gone—for the method is still in the experimental stage—that by this method all forms of blood pigment may be fixed in this way.

It is, we find, of no service whatever in preserving the colour produced by the staining of the tissues with bile.

The process is a somewhat long and tedious one, and requires a considerable amount of careful supervision; but I think you will agree with me in pronouncing it a wonderful improvement upon the old style.

No. 3.—TUBERCULOSIS AND THE PUBLIC HEALTH.

By George Lane Mullins, M.A., M.D., F.S.S., F.R.M.S.

(Read Friday, January 7, 1898.)

[*Abstract.*]

During the past forty years (1857–96) there have been nearly 34,000 deaths from tuberculosis in the Colony of New South Wales.

During the years 1885–96, there were 17,114 deaths from tubercular diseases in the Colony, while there were 12,884 from the six chief zymotic diseases—viz., smallpox, measles, scarlet fever, whooping cough, diphtheria, and typhoid fever.

Within the metropolitan area (Sydney and suburbs) there were 4,726 deaths from tuberculosis, and 2,925 from these zymotic diseases, during 1890–96. Immense sums of money are spent every year in the prevention of infectious fevers, yet the most deadly disease in the world is neglected. Fevers usually attack children, run a short course, protect from subsequent occurrence, and leave their subjects able to work. Tuberculosis, on the other hand, strikes down those in the prime of life, runs a chronic course, and causes permanent incapacity for occupation. Tuberculosis is a communicable disease. Experiments have demonstrated this clearly. This communicability being granted, it is our duty to protect the healthy members of the community against the ravages of the disease.

Tuberculosis is caused by the tubercle bacillus of Koch, which gains an entrance to the body from without. It affects man and many of the domestic animals, such as cattle, horses, and pigs. Heredity plays a very unimportant part in the production of the

disease, and this mode of infection must be extremely rare. It is the predisposition which is so often confounded with the transmission of the disease. The chief modes of communication are inhalation and ingestion; but the disease may be inoculated. The bacilli may be received from the air by inhalation, and from tuberculous food, such as milk or meat, by ingestion. Probably, in adults at any rate, inhalation is the chief mode, and next to that ingestion.

There are some who doubt the identity of human and bovine tuberculosis; but there are on record numerous instances of infection from human beings to lower animals, from one animal to another, and from the lower animals to man. Where cattle are few or absent, consumption exists in man to a such smaller extent. Where cattle are numerous, or are kept in the houses, tubercular diseases are frequent both in man and the lower animals. Dr. Creighton believes that the peculiar errors of nutrition in the domesticated bovine species all over the world are the real fountain and source of human tubercle.

That tuberculous milk may, and frequently does, cause tuberculosis in human beings is beyond all doubt. The milk containing the tubercle bacilli enters the mouth and passes on to the throat. During the time of its passage the bacilli may be deposited in the mouth, tonsils, pharynx, or adjacent structures. More bacilli are added every two, three, or four hours, according to the frequency of feeding. These bacilli may be washed further down and into the stomach, or may cause infection in the mouth, &c., or may be inhaled into the lungs. The milk that passes into the stomach may deposit more bacilli, or may continue on its journey into the intestines. Strauss and Würtz have shown that the bactericidal quality of the gastric secretions is insufficient to destroy the bacillus tuberculosis. Infection may thus arise in the mouth, tonsils, throat, lungs, or intestinal canal from tuberculous milk. The lung infection may be primary from direct inhalation of the bacilli lodged in the mouth, or may be secondary to infection of other parts.

Woodhead reports that in 127 cases of tuberculosis in children that he examined, tubercular ulceration of the intestine was found in 43; whilst in 100 cases, or nearly 79 per cent. of the whole, the glands connected with the intestinal tract were in some stage or other of tubercular degeneration. He argues that tuberculosis connected with the intestine is of frequent occurrence in children, and that the infection frequently takes place by the alimentary canal. The age at which these tubercular glands were found is very significant. During the first year of life there were 4 cases; from 1 to $2\frac{1}{2}$ years, 33; from 3 to $5\frac{1}{2}$ years, 29; from 6 to $7\frac{1}{2}$ years, 12; from 8 to 10 years, 13; and from 11 to 15 years, 9 cases. In 14 cases these glands only were affected.

Thorough cleanliness of dairy premises, workers, cows, and vessels should be rigidly enforced. All cattle should be tested with tuberculin, and strict isolation of those reacting to the test should be enforced. The public should demand from dairymen a certificate from an expert that the dairy contains no tuberculous animals. No cattle should be admitted to a dairy until they have passed the test. Tuberculosis in man should be declared an infectious disease under section 12 of the Dairies Supervision Act of 1886. No consumptive should be allowed access to dairies or to take part in milk-selling. All milk should be sterilised by boiling, or it should be Pasteurised. No cattle should be allowed to enter the Colony until they have passed the tuberculin test.

The danger from tuberculous meat is not so great as that from the milk of infected cows. Meat being cooked before it is eaten is more likely to have the bacilli it contains destroyed, except in the case of large joints, or when imperfectly cooked. It has been shown that no matter how high the temperature may be raised near the surface of a joint, the heat rarely exceeds 140 degrees Fahrenheit in the centre, except when the joint is under 6 lb. in weight. Ordinary cooking may destroy any tubercle bacilli on the surface, but it cannot be relied upon in the slightest degree to destroy those in the centre. The least reliable method of cooking for this purpose is roasting before the fire, next comes roasting in an oven, and then boiling. In the present state of our knowledge regarding tuberculous meat it is advisable to condemn the whole carcase of any animal slaughtered for food in which even localised tubercular lesions are found. This is now the practice in Sydney, and there appears to be no reason for altering it.

On the general subject of prevention of the disease, the following rules may be laid down:—

Overcrowding should be prevented. This overcrowding may be of two kinds. A district may consist of a large number of small houses, built back to back, and without yard space. The streets may be narrow, or may end in blind alleys; or, in the poorer quarters of towns, a large number of persons may live in small houses—sometimes even whole families, consisting of perhaps seven or eight persons, may inhabit one or two rooms.

Sunlight and fresh air should be allowed free access to all habitations. Sunlight alone is a valuable germicide. The houses should be well ventilated. A broken pane of glass in a badly-ventilated house often does more good than harm. The subsoil should be well drained.

All rooms should be well swept while the windows are open. The old-fashioned plan of sprinkling tea-leaves on the floor is to be recommended, as it serves to prevent the dust from rising and afterwards settling down in the room. All houses intended for habitation should be inspected by public officers before they are

used for residence. Dirty trades should be regulated, and all buildings subjected to periodical sanitary inspection.

Consumptives should be isolated as far as possible. They should spit into small pieces of rag or paper, which can be burned, or into a small spitting-cup containing an antiseptic solution, such as carbolic acid or corrosive sublimate. They should sleep in well-aired rooms by themselves, and should not have more communication with the other members of the household than is absolutely necessary. They should not marry.

Consumptive children should not be admitted to boarding-schools unless they can have separate rooms for sleeping in, and provision can be made for the destruction of the expectoration.

Consumptive mothers should not nurse their children, nor should phthisical wet-nurses be employed.

We cannot allow phthisical patients to enter the wards of our general hospitals for treatment, for we are unable to prevent communication between the consumptive and other patients in these institutions. Experiment has shown that the air which a consumptive breathes becomes charged with the bacilli of tuberculosis ; the expectoration, which is usually copious, dries up and leaves the bacilli to mingle with the dust in the room, and cause infection among others. If then, consumptive patients occupied the same wards with others in the hospitals, they might communicate the malady to those who are debilitated by disease or accident. The power of resisting disease is at a minimum among hospital patients, and thus they are peculiarly susceptible to the bacilli, to which they fall an easy prey. In time, then, every ward would become a permanent centre of contagion.

There are many objections to a large consumptive hospital within our city boundaries. While the segregation of consumptives might be beneficial to the community at large, their isolation in the bacilli-laden atmosphere of the town must prove injurious to the patients themselves ; but the plan of erecting a home for those who are in too advanced a stage to travel to the country districts and benefit by the climatic treatment is an excellent one. A small building containing a few beds would be ample for such cases. To this institution an outdoor department should be attached where patients who are unable to leave the city might be treated in the early stages. Such a hospital, together with the existing Hospice for the Dying in Darlinghurst, would be as much as it would be wise to establish. If a patient be found to be suffering from phthisis, and removal from the impure air of the city be impracticable, he might be treated as an out-patient, but such cases should not be treated within the walls of a city building. A small hospital should be established in Sydney, together with three or four homes in the country districts, which might be used by those who are in the curative stage, or in the

progressive stage before all hope is abandoned. A large consumptive hospital in the city is very objectionable.

At the Brisbane meeting of this Association, the writer contributed a paper showing the death rate from phthisis in every district in New South Wales. These figures showed that in Sydney the rate was 1·96 ; suburbs, 1·16 ; country, 0·66 ; or the ratio for city, suburbs, and country, of 3, 2, 1. Probably the most suitable locations for country sanatoria would be on the western slope of the Blue Mountains, the Riverina, New England, the Queensland border, on those extensive open plains between the Macintyre and Gwydir Rivers. A coastal station might be established in the Illarwarra or Shoalhaven districts. In Europe and in America the climatic treatment of phthisis has met with gratifying results. There are in Australia many and varied climates which, so far, no serious attempt has been made to take advantage of.

What is required most is the sanitary education of the masses, and the co-operation of individual members of the community. The public must be made to understand that consumption is a preventable disease ; that their lives depend, to a great extent, upon the actions of one another ; and that the causes of preventable diseases are local conditions of filth and nuisance polluting air and water, and the reckless dissemination of contagion.

No. 4.—A BRIEF SKETCH OF THE HISTORY OF SMALL-POX AND VACCINATION IN NEW SOUTH WALES.

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[*Abstract.*]

I. SMALL-POX.

The exact time of the first appearance of small-pox in Australia has generally been referred to too late a date, mainly on the authority of Hirsch. In his "Geographical and Historical Pathology," New Syd. Soc. Trans., London, 1885, vol. i, page 133, this writer states that small-pox did not appear in Australia till the year 1838, that its occurrence then was of brief duration, and that no further outbreak occurred until 1868.

Davidson ("Geographical Pathology") considers that Hirsch's statement can only have reference to the European population, since small-pox was prevalent amongst the native blacks in 1789, shortly after the first settlement of the English in Australia.

As will be seen from the following summary of the official records relating to the matter, the early history of Australia furnishes somewhat abundant evidence in support of Davidson's contention.

The colonisation of New South Wales was instituted at Sydney, Port Jackson, on January 26th, 1788, by the arrival of what is known as the "First Fleet," consisting of eleven vessels, carrying about 1,000 persons. No addition was made to the English inhabitants of the English settlement till the arrival of the "Second Fleet" in 1790.

In the meantime, in April, 1789, the native blacks in the neighbourhood of Sydney were found to be dying in large numbers; their bodies were discovered on the rocks and beaches of the harbour and elsewhere. The cause of this great mortality remained unknown until a sick family was brought into the settlement, when the disorder was pronounced to be small-pox. Two elderly men, a boy, and a girl, comprised the family brought in. They were all affected with the disease. The two men died, the children recovered. A young male native, previously captured, caught the disease from his countrymen, and died from it. One other person, a sailor (negro or North American Indian), also succumbed to the disease. None of the whites became infected, although there were many unvaccinated persons amongst them.

The blacks fled from the vicinity of Sydney, but apparently carried the disease with them. At later dates exploring parties from the settlement found groups of skeletons in various directions. Many writers have testified that the blacks met with by them in various parts of the continent were pitted with small-pox. Such pock-marked blacks were observed at Perth, at the time of the first settlement there (1829), and later at other places on the western and northern coasts; in the south at Port Phillip, on the Lower Murray at Swan Hill (1838), on the Goulburn River (1841), in the north at Raffles Bay (1828), &c.

In his "History of Leprosy in Australia," recently published by the National Leprosy Fund Committee, Dr. J. Ashburton Thompson refers to an observation made in 1828. Quoting from "A Narrative of a Voyage Round the World," by T. B. Wilson, M.D., London, 1829, who was wrecked at Cape York in 1828, and reached Raffles Bay soon after, Dr. Thompson writes as follows:—"The only sentence in which diseases of the aboriginals were mentioned by Dr. Wilson spoke of a party who were all suffering from bronchitis, of ophthalmia, and of 'deep, circular impressions, especially on the face,' as though they had had

small-pox, which, after some inquiry, he concluded was the disease to which they were due, and the more that one native had lost an eye during the illness which had caused them," In this we have a particularly independent observation of the early occurrence of small-pox amongst the blacks.

At the first census of the blacks of Victoria in 1877, five old persons were found pitted with small-pox. One of these furnished the information that the disease first came to his tribe down the Murray (*i.e.*, from the direction of Sydney), many years before they had seen or heard of the whites. Actual cases of the disease amongst the blacks were reported at Bathurst, New South Wales, in 1830–1831 (where three white children became infected, and one died); in the neighbourhood of Adelaide, South Australia, at about the same time; and at Echuca, Victoria, between 1841 and 1845.

The inference which has been drawn from this *résumé* of the early records is that an epidemic starting from Sydney in 1789, spread during the succeeding years over the whole of the continent; that it was maintained till 1845, shortly after which it appears to have died out. There is abundant evidence that during its prevalence it produced an enormous mortality amongst the blacks, about one-half of the native inhabitants of the southern part of Australia having been killed by it. Notwithstanding this great loss of life amongst the blacks, the whites escaped. From first to last, probably not more than half-a-dozen white persons acquired the disease.

This fact has led to some doubt as to the disease having been small-pox, but it does not seem to merit such import being attached to it. A similar almost exclusive incidence on a native race has been observed in other countries, and with other diseases. It is not difficult to suppose that the whites took the utmost care to avoid infection from a disease the contagiousness of which they were well aware of. It is probable that the "race tolerance" of the whites against small-pox played its part in protecting them, and, as will be seen later, vaccination began to be practised early in 1804. Every medical man who saw the disease, or the scars left by it, pronounced it to be small-pox. No disease peculiar to the blacks has been discovered which could produce such effects, and vaccination was said to be specific against it. In view of all these circumstances there does not appear to be any satisfactory foundation for the doubts which have been expressed; but, on the contrary, all available evidence tends to prove that the disease was really variola.

There is no evidence of any previous existence of the small-pox in Australia. The account of the epidemic given above indicates that it started from Sydney in 1789. The records referring to it state that there had never been small-pox in the English settlement.

Efforts to discover its source, made at the time of its first appearance, failed to determine whether the blacks had had any previous knowledge of it ; it was found that they had a name for the disease (*gal-gal-la*), and this was supposed to indicate a pre-acquaintance with it ; but exactly what *gal-gal-la* means is uncertain. It is only a local name, since in other parts of the continent the blacks referred to small-pox as *ouie* or *boie*, *purrer purrer*, *meen waranna*, &c. The absence of a root-relation between such terms indicates that at least the disease appeared amongst them at a comparatively late period—long after the separation of the various tribes. There is thus evidence that the disease was imported by some other race. The initial incidence on the southern part of the continent negatives the idea of importation by Malays or Chinese such as, it is believed, occurred in a subsequent epidemic. The earlier Spanish, Dutch, and English navigators who touched the coast of Australia, were probably not in such communication with the blacks as would have sufficed to introduce the disease. The earliest accounts we have of the blacks are those of Dampier (1699), and Captain Cook (1770). Dampier makes no mention of any disease resembling small-pox amongst the blacks, although those he saw were in a neighbourhood (Sharks Bay, Western Australia) in which small-pox was afterwards common. In Cook's account of the blacks at Botany Bay and the Endeavour River, it is noted that there was no skin disease amongst them. Mr. Curr remarks that several independent traditions of the blacks, "which there can be no doubt are genuine," refer to the original source of the disease to the direction of Sydney. The devastation which the epidemic of 1789 produced indicates that it was incident on a virgin population, and one to whom it was an entirely new experience. These considerations seem sufficient to warrant the assumption that the epidemic above described marked the introduction of small-pox into Australia.

The exact source of the epidemic is involved in obscurity. It has already been mentioned that there had been no small-pox in the English settlement before the blacks became affected. An opinion very generally expressed at the time was that the disease was derived from two French ships under the command of Comte de la Perouse, which remained for about two months at Botany Bay at the time of the foundation of the colony—January to March, 1788 ; but there is no reason to believe that small-pox existed amongst the crews of these vessels ; moreover, the epidemic did not appear till fifteen months after they had sailed away. There are certain circumstances connected with the medical history of the "First Fleet," which arouse suspicion that responsibility of the introduction attaches to it. It was said that, before leaving Plymouth, the ship's company of the "Alexandria" transport had "got a malignant disease amongst them of a most dangerous

kind." Dr. John White, the surgeon-general of the First Fleet, did not agree with this opinion. The name of the "malignant disease" was not stated, nor were the deaths that occurred during the voyage particularised. Captain Trench, referring to the voyage of the First Fleet, says: "No person amongst us had been affected with the disorder (small-pox) since leaving the Cape of Good Hope," a statement which induces the inference that there was small-pox on board before that time. It is possible, therefore, that the "Alexandria," or some other vessel of the First Fleet, carried the infection to Sydney, and from the settlement there it was subsequently conveyed to the blacks, perhaps by means of infected clothing or some other article, as in the case of the North American Indians. However, it must be admitted that there is little more than surmise to go upon, and that the precise way in which small-pox was introduced into Australia remains undetermined.

Such, in brief, is the history of what appears to be the first appearance of small-pox in Australia. The disease was mainly incident on that part of the continent south of the tropic of Capricorn. There seems to have been a second epidemic amongst the blacks in 1860–61, this time apparently limited to Northern Australia. The blacks suffered severely, but the whites escaped as before. On this occasion the disease is believed to have been introduced by Malays or Chinese fishermen.

About this time the colonies of Victoria and Queensland were separated off from what is now New South Wales. As regards this latter province, the importation of small-pox has threatened or actually occurred on several occasions, and formed the subject of Board of Health reports in 1881–1882, 1883–1884, 1886 (s.s. "Oceanien"), 1887 (s.s. "Preussen"), and 1892 (R.M.S. "Oroya"). The most important of these invasions was the epidemic of 1881–1882, which lasted from May, 1881, to February, 1882, during which time 154 persons were attacked, and forty died. One result of this epidemic was the passing of the "Infectious Disease Supervision Act of 1881," which requires immediate notification of "any case of small-pox or any eruptive fever which may reasonably be supposed to be small-pox." A Board of Health was constituted by the Act, and directed to carry out its provisions, as well as those of the Quarantine Act of 1832. Both of the Acts, amended in certain particulars, are still in force, and the Board continues to discharge its duties under them.

The system of maritime quarantine practised in this country is generally well-known. The exact details of the procedure will be found in the Report of the Australian Sanitary Conference of 1884, and in the Board of Health's reports concerning the quarantine of particular vessels.

II. VACCINATION.

It is a deplorable fact that this system of quarantine has led to neglect of vaccination.

The surgeons of the "First Fleet" are said to have brought out "variolous matter" with them. Exactly what is meant by "variolous matter" is not clear, but in any case there is no record of their ever having made use of it.

On the 4th of May, 1803, Captain Phillip Gidley King, R.N., the Governor of New South Wales, addressed a letter to Lord Hobart, Secretary of State, suggesting that "vaccine matter" should be sent to the Colony. In this letter he states that "every search has been made on the teats of our cows (for cow-pox) but nothing of the kind can be found." In response to the Governor's letter a supply of vaccine lympth, obtained from the Royal Jennerian Society, was despatched in the "Coromandell" transport, which arrived in Sydney, on May 7th 1804. By the same vessel there also arrived a second packet of lymph forwarded to Assistant Surgeon Savage, by Mr. John Ring, Member of the Medical Council, which was "put up in a different way from that sent by the Royal Jennerian Society."

On receipt of the lymph, the principal surgeon (Dr Thomas Jamieson), immediately vaccinated three children at the Orphan Asylum; several of the soldiers' children were vaccinated by Mr. John Harris, surgeon to the New South Wales Corps; and some other persons by Mr. Savage.

Their efforts were successful, for a notice which appeared on June 3rd, 1804, stated that "the cow-pox is now fully established in the Colony," and invited parents to have their children vaccinated. This invitation appears to have been generally accepted, since Governor King, on sending some "vaccine matter" to Norfolk Island, in July, 1804, wrote—(vaccination) "succeeded so well here that most part of the children in the Colony have received the inoculation."

After this, vaccine lymph appears to have died out and been reintroduced at intervals, the supplies coming from England, and in one instance, at least, from Norfolk Island.

More recently the Colony has had a constant though small supply, derived from England until 1881, and since that time from Victoria and New Zealand, both of which colonies have established vaccine stations. No lymph is cultivated in New South Wales, though the necessity for it has been frequently urged, and the disastrous effects of such unpreparedness, which may be expected should an epidemic occur, have been pointed out time after time.

New South Wales also occupies the unenviable position of being the only province of the Australian group in which an enactment for compulsory vaccination does not exist, although strong representations in favour of such legislation have not been wanting. The Colony thus constitutes a danger and a menace to the other colonies, of which the latter have just cause to complain.

The subjoined table shows the number of persons vaccinated by the Government Medical Officers since 1861, together with the number of births, and the proportion of vaccinations to births. It does not include vaccinations performed by private medical practitioners, of which no record is kept; but these are believed to be too few to materially influence the percentages given in the table:—

Return showing the number of Births during the past thirty-six years, and the number of Vaccinations performed by Government Vaccinators during the same period.

Year.	Births.	Vaccinations.	Proportion of Vaccinations to every 100 Births registered.	Year.	Births.	Vaccinations.	Proportion of Vaccinations to every 100 Births registered.
1861	14,681	2,349	16·00	1880	28,162	5,029	17·85
1862	15,434	3,155	20·44	1881	28,993	61,239	211·21
1863	15,679	12,970	82·72	1882	29,702	2,188	7·36
1864	16,881	10,696	63·36	1883	31,281	882	2·81
1865	17,283	8,367	48·41	1884	33,946	7,055	20·78
1866	16,950	7,606	44·87	1885	35,043	2,230	6·36
1867	18,317	6,931	37·83	1886	36,284	1,763	4·85
1868	18,485	11,237	60·79	1887	37,236	3,230	8·67
1869	19,243	21,507	111·76	1888	38,525	2,186	5·67
1870	19,648	7,084	36·54	1889	37,295	2,404	6·45
1871	20,143	6,482	32·16	1890	38,960	2,197	5·64
1872	20,250	17,565	86·74	1891	39,458	1,567	3·97
1873	21,444	3,152	14·69	1892	40,041	4,014	10·02
1874	22,178	4,832	21·78	1893	40,342	2,547	6·31
1875	22,528	3,111	13·80	1894	38,952	1,957	5·02
1876	23,298	4,361	18·71	1895	38,715	2,437	6·29
1877	23,851	16,881	70·77	1896	36,613	945	2·59
1878	25,328	3,512	13·86				
1879	26,933	5,569	20·67	Total	988,102	258,821	26·19

This table tells a dismal story of constantly increasing apathy towards vaccination. In succeeding years the proportion of vaccinations to births has become less and less, until at the present time we are practically an unvaccinated community. Here and there sudden temporary increases in the proportion show when the importation of the disease threatened, as at such times the number of persons submitting themselves for vaccination largely increased.

This singular apathy is to be attributed to three chief causes: First, there is the suspicion which still remains that vaccination is accompanied by the inoculation of various diseases (syphilis, leprosy, and the like)—a suspicion which no amount of proof to the contrary seems able to remove from ignorant minds. Secondly, there is the fact that on the one or two occasions when small-pox actually gained an entrance it failed to spread to any extent, in spite of the number of unvaccinated persons. The limitation of the disease in these cases was due partly, no doubt, to the energetic measures which were taken to check its extension, but it is believed that it was not entirely due to these. There was some other fortunate, but unknown, condition which opposed a barrier to the progress of the epidemic. However this be, these circumstances afford no guarantee against future invasion. The history of the epidemic amongst the blacks shows that there is no climatic influence operating in our favour, and in view of what has happened amongst civilised nations we cannot rely on our social conditions alone to protect us. Thirdly, and most important of the three, there is the misguided reliance which is placed on our system of maritime quarantine. Although it is admitted that this system has many obvious advantages favouring its practice in this country, the folly of depending on it for more protection than it can possibly afford has been remarked upon by successive chiefs of the Health Department. Moreover, its advantages are considerably diminished by the lack of uniformity in the quarantine measures of the different colonies. A system of Federal Quarantine has been suggested, but has not found any practical application. That small-pox will some day or other effect an entry in spite of the utmost watchfulness is the firm belief of all those who have interested themselves in the subject.

The above sketch will show the position of New South Wales as regards vaccination. Too far removed from the countries of the Old World to be impressed by their experiences of small-pox, and lacking the salutary effect (as regards vaccination) of previous serious contact with the disease, the people of this colony remain to-day unwise as to their own interests, and indifferent towards those of their neighbours.

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SECTION J.

MENTAL SCIENCE AND EDUCATION.

PRESIDENTIAL ADDRESS.

By JOHN SHIRLEY, B.Sc., District Inspector of Schools, Queensland.

(Delivered Friday, January 7, 1898.)

THE INFLUENCE OF ENGLISH HISTORY ON ENGLISH LITERATURE.

THE history of England might be represented graphically by an irregular wavy line, whose crests would depict years of victory, prosperity, and expansion, and whose furrows would show periods of loss, of civil conflict, and of depression. If, now, we insert dates on these historical summits, it will be found that periods of great national success are synchronous with times of great literary activity; and that when the heart of the nation is stirred to its depths by threatened peril, only to be successfully avoided by mighty effort and sacrifice, a few master-minds of the age, unconsciously, and almost Divinely inspired, give tongue, in prose or verse, to the joy, or thankfulness, or exaltation, felt by the mass of their fellow-countrymen, though inarticulate in all but the selected few. Occasionally, the genius is born after the national uplifting has ceased, or, still worse, before the nation is *in excelsis*; but, like the Hebrew prophets of old, when once the message has been given, it is delivered, whether in season or out of season, whether the outcome be acclamation or persecution. Not rarely, in times of misery, the groans of the oppressed are voiced in the lamentations of a Piers Plowman, or by the *Vox Clamantis* of a Gower; but the agony, however sincerely expressed, is seldom accompanied by talents above mediocrity. Again, both in history and literature, there are periods of dull contentment, or of national high living, when wit and patriotism are obscured, and the Philistine is abroad in the land.

A wholly false idea has possessed many writers with regard to that portion of English literature which was produced prior to the Norman Conquest, and its connection with the main stream of English thought. Even such a critic as Professor Craik has permitted himself to write: "Of English literature, and the English language commonly so called, the language and literature of the Angles and Saxons before the twelfth century make no proper part." Much has been done by recent writers, like Morley and Stopford Brooke, to clear away the dense mists of ignorance concerning this matter. There was first an era of English, or, shall we say, Anglo-Saxon poetry, beginning in the older England east of the North Sea, and ending with the accession of Alfred; and an era of early English prose, cmomencing in Wessex with the firm establishment of Alfred's power, and continuing in a broken stream to the fusion of two languages and two nations in the English of the twelfth century. The first of these eras marks the overlordship of Northumbria; the second, that of Wessex. The kingdom of Northumbria received its Christianity from Celtic missionaries; its borders marched with those of the Britons of Strathclyde, the Scots of Argyle, and the Picts beyond the Forth; and there is evidence of a certain amount of fusion between the two races. This blending of Celt and Saxon has most powerfully affected English literature in all its stages. It has been compared to the addition of leaven to the other bread-forming materials; and its effect in the endowment of talent has been most potent and palpable.

Of the Germanic tribes which achieved the conquest of Southern Britain, the Angles, in their ancient seats north of the Elbe, were most removed from the civilization of the age; yet, in this race of savage warriors, the germs of poetry and of letters were first exhibited.

Of the Northumbrian poetry, the Rev. Stopford Brooke says: "With the exception of perhaps a few Welsh and Irish poems, it is the only vernacular poetry in Europe, outside of the classic tongues, which belongs to as early a time as the seventh or eighth centuries. The Welsh and Irish poems are few and problematical, and their range is limited; but the English poems are numerous, well authenticated, and of a wide and varied range. In these two centuries our forefathers produced examples, and good examples for the time, of religious, narrative, elegiac, descriptive, and even, in some sort, of epic poetry.

"And the ideal and sentimental elements of the earliest poetry have continued with natural changes to the present day.

"Here too, we can best discern, and here isolate most easily, those elements in English character, which, existing before the race was mixed, have been, not the cause of our poetry, but the cause why the poetry has been of so high an excellence,—that

steady consistency of natural character—that clinging through all difficulty to the aim in view—that unrelenting curiosity—that desire to better what has been done * * * which * * * powers enable art to strive, to seek, and at last to reach its goal.

"Moreover no national art is good which is not plainly that nation's own. In this Anglo-Saxon poetry * * * we grasp most closely the dominant English essence. The poetry of England has owed much to the different races which mingled with the original English race; it has owed much to the different types of poetry it absorbed--Greek, Latin, Welsh, French, Italian, Spanish; but, below all these admixtures, the English nature wrought its steady will. It seized, it transmuted, it modified, it mastered these admixtures both of race and song."

To a nation which recalls with pride its long roll of heroic seamen, it is a source of the keenest pleasure to find that the early Northumbrian poetry has for its constant theme the ocean. The sea in all its moods—its joys, its perils, its heroes,—is the stage upon which the characters of early English poets play their parts. The winds, the billows, the rocks, the ocean caves, the monsters of the deep, are all familar subjects.

Of *Beowulf*, the earliest specimen of English poetry, it has been said:

"The background of all the action is the great deep—the chorus, as it were, of this story of the fates of men. Thus, the ocean life, the ocean mystery, the battle with the ocean, and on the ocean, began the English poetry; and they are as vivid in it now as they were in the youth of our people. *The Battle of the Baltic*, *The Fight of the Revenge*, *The Sailor Boy*, *Hervé Riel*, Swinburne's Sea-songs, a hundred ballads, taste of the same brine and foam which the winds drove in the faces of the men who wrote *Beowulf*, *The Seafarer*, and *The Riddles* which concern the sea. Nay, more, the very temper of mind which pervades modern poetry of the sea—a mingling of melancholy and exaltation—is to be found in English poetry before the Conquest; and strange to say it is not found again, except in scattered ballads, till we reach our own century.

"There is in *Beowulf* no trace of any dread of the sea, even in its worst moods, nor do the men complain of the labours of the ocean, or of its icy weathers."

As Sidonius says of the pirate Saxons:—"They know the dangers of the ocean as men who are every day in touch with them. In the midst of tempests, and skirting the sea-beaten rocks, they risk their attack with joy, hoping to make profit out of the very storm."

Although usually regarded as a simple matter, it is, in fact, a most difficult task to determine when the English language, in its modern form, really commenced. The language of the Anglo-

Saxons lost many of its inflections before the Conquest, and the succession of verbal changes was so gradual and constant that at no period can anything except an arbitrary line be drawn. Hallam, in his review of the literature of Europe, says:—"When we compare the earliest English of the thirteenth century with the Anglo-Saxon of the twelfth, it seems hard to pronounce why it should pass for a separate language, rather than a modification or simplification of the former."

These changes were hastened by the Norman Conquest, and proceeded at an accelerated rate throuth the eleventh and twelfth centuries; but they were brought to a climax in John's reign. The loss of Normandy, and the adjacent northern provinces of France, put an end to the intimate connection between England and the Continent, deprived the Norman nobles of their fiefs across the Channel, and prevented them from making those frequent visits to Normandy which had been common under the sovereigns from William to Richard.

In this period of rapid change the borderland of Celt and Saxon is again the home of the greatest literary activity. Geoffrey of Monmouth, Gerald de Barri, and Walter Map, were Welsh on one or both sides; Orderic hailed from Shrewsbury, and Layamon lived at Ernley, to the west of the Severn. These writers dealt mainly with history or historical legends; and to four of them we owe the rescue from oblivion of the Arthurian stories, which, having been told in Latin and French, were first given in English of the transition period by Layamon.

Arthur and his Knights of the Round Table have proved a perfect mine of wealth to the poets of the last ten centuries in all European nations; and Tennyson has shown in our own times that the store is not yet exhausted.

The paucity of English writers in the two centuries before the appearance of Chaucer is no matter for surprise. The language of a country during a period of rapid change is neither exact enough, nor polished sufficiently, to act as a channel of communication between the master minds of the age and their many silent contemporaries. In his philological and grammatical observations, M. Reynouard embodies this principle in the following dictum: "There has never been composed any considerable work in any language till it has acquired determinate forms of expressing the modifications of ideas according to time, number, and person," or, in other words, the fixed elements of grammar.

Until the middle of the fourteenth century the literary requirements of the English court, and of the English nobility, were mainly supplied by French writers. The first literature in any native language derived from the Latin was that of the Provençal Troubadours, mainly in praise of love, which soon extended to the northern provinces speaking the *Langue d'oćil*, or old French.

These northern writers, however, soon adopted as their own a different poetical field—that of the metrical romance. In the thirteenth century, French was the language of the courts of England, France, Italy, and Germany.

Chaucer, as a page, soldier, court official, and ambassador, would be well acquainted with the poetry of the Troubadours, and his first attempts were translations of French lays, like the *Roman de la Rose*. Of this poem it has been aptly remarked: "Over a large part of Europe it supplied poets, for a century and more, with their chief model for the shaping of an allegory" This "poem which closed in France the literature of the Middle Ages, maintained its supremacy until the invention of printing, and many editions of it were published in the fifteenth century,"

The literature of Southern Europe could have been no sealed book to Chaucer, whose wife, after the death of Queen Philippa, in 1369, was in the service of Constance of Castile, second wife of John of Gaunt—Chaucer's patron. In 1372, and again in 1378, Chaucer was sent on political missions to Italy. On his first journey he visited Genoa and Florence, and on the second visit he was accredited to Bernardo Visconti, Lord of Milan, and Sir John Hawkwood, the celebrated English captain of free-lances.

Italy was the last of the Latinised countries to produce an independent language and literature. No industry will reveal even so much as a few lines of real Italian until the end of the twelfth century. In the fourteenth century appeared Dante, Petrarch, and Boccacio. To the second of these we owe the popularity of the sonnet, and the third is the father of all prose fiction.

Under the influence of the Troubadours Chaucer became a poet; under the influence of Dante and his Italian contemporaries Chaucer became a genius. Of this writer Tyrwhitt remarks: "Chaucer is the Homer of his country, not only as having been the earliest of her poets, but also as being still one of her greatest. The names of Spenser, of Shakespeare, and of Milton, are the only other names that can be placed on the same line with his." This statement is only in part correct, and a better appreciation of Chaucer's position is thus stated by John Morley: "The genius of Geoffrey Chaucer is not to be likened to a lone star glittering down on us through a rift in surrounding darkness, or to a spring day in the midst of winter, leaving us to wait long for its next fellow. He had in his own time for brother writers, Wyclif, Langland, Gower—some of the worthiest men of our race —and the light of the English mind was not quenched when he died."

After the times of Chaucer, and of his contemporaries—Barbour, Lydgate, and Gower,—came the long period of unrest following the usurpation of Henry IV, and culminating in thirty years of

civil warfare, which stamped out, by constant slaughter, the effects of Chaucer's genius and example. The one gleam of light during the Wars of the Roses was the institution of printing by movable type, which commenced at Haarlem, was perfected at Mayence, and rapidly introduced into France, Italy, and England. After the death of Lydgate no English poet arose worthy of mention until we meet with Hawes in the early part of the sixteenth century. His *Pastime of Pleasure, or the Historie of Graunde Amour, and La Bel Pucel*, was printed in 1517.

There is a most peculiar parallel between Hawes and Bunyan. Hallam remarks: "Their inventions are of the same class, various and novel, though with no remarkable persistence to the leading subject, or naturally consecutive order; their characters, though abstract in name, have a personal truth about them, * * * They render the general allegory subservient to inculcating a system—the one of philosophy, the other of religion."

The peaceful and comparatively prosperous reign of Henry VIII gave England once more a place among nations, and her alliance was alternately solicited by France and Spain. Under Wolsey's rule the nation prospered, and intercourse with foreign countries, particularly with Spain, was largely extended. Throughout the Tudor period Spain was the most powerful country in Europe, and the marriages of members of the English and Spanish royal families made Spanish the court language of the period. Speaking of the Spanish writer, Guevara, author of *Marco Aurelio, or the Golden Book*, Hallam says: "This sententious and antithetical style of the Spanish writers is worthy of our attention, for it was imitated by their English admirers, and formed a style much in vogue in the reigns of Elizabeth and James." At this era Spain was the principal power in the Italian States, and the Italian poetry was well known in Spain, and greatly admired. Dante, Petrarch, and Boccacio, so familiar to Chaucer, had been forgotten during the long period of civil strife. "In the latter end of King Henry VIII's reign," says Puttenham in his *Art of Poesie* "sprang up a new company of courtly makers, of whom Sir Thomas Wyatt the elder, and Henry, Earl of Surrey, were the two chieftains, who, having travelled into Italy, and there tasted the sweet and stately measures and style of the Italian poesie, as novices newly crept out of the schools of Dante, Ariosto, and Petrarch, they greatly polished our rude and vulgar manner of homely poesie, from that it had been before, and for that cause may justly be sayd the first reformers of our English meeter and stile. In the same time, or not long after, was the Lord Nicholas Vaux, a man of much facilitie in vulgar makings."

In this age chivalry was not yet dead, and the era of exploration and adventure had begun. Thirty years of civil strife had made

Englishmen a nation of soldiers, and the English character was hardened and tempered by rigid parental authority at home, and the inflexible, not to say brutal discipline of the schools.

Of English thought in the sixteenth century, Wyatt and Surrey were the early exponents.

"They were men whose minds may be said to have been cast in the same mould, for they differ only in those minute shades of character which always must exist in human nature; shades of difference so infinitely varied that there never were and never will be two persons in all respects alike."

They were typical samples of the northern races of Europe; each was imbued with a love of virtue for its own sake, and each had an instinctive repugnance for vice and mental cowardice. They were prompt in action and keen for adventure, as befitted men who saw the exploitation of a new world; they were constant in friendship; they loved like men, and not like angels; they were unselfish, and careless of praise, yet unstinting in their recognition of merit in others.

Wyatt was the better judge of character, and his irony is searching and pungent, and by making vice ridiculous tends to reformation. Surrey was a keen observer of Nature, and delighted in that communion with her in all her moods, which has such a charm for English hearts.

Surrey's taste and literary judgment were alike excellent. His translations from Petrarch do no injustice to his Italian master; and, by his introduction of blank verse into English poetry, he prepared the way for his great successors, Shakespeare and Milton. Surrey employed this form of poetry in the translation of the second book of the Æneid, which may be regarded as one of his most successful compositions.

In his choice of words Surrey avoids the ponderous terms filched from the Latin, so loved of Hoccleve, Lydgate, Dunbar, Douglas, and other of his predecessors—both Scots and English. His terms, too, are applied with a clearly-defined meaning, wholly unlike the wide range of application given by Chaucer's disciples to their selected Latin epithets.

According to Nott, Surrey deserves the still more conspicuous praise of having brought about a great revolution in our poetical numbers. Much archaic English seems to have been preserved in the poetry of the age preceding Wyatt and Surrey. These writers brought English verbal quantities into line with the accepted pronunciation of the day; they rarely lay an unnatural stress on final syllables, and they ceased to give value to mute vowels long silent in colloquial English.

If we compare the poetry of Wyatt and Surrey with that of men like Barclay and Skelton, who preceded them by some thirty or forty years, the contrast is striking, so much more do the first-

named writers approach in their composition the English of to-day; and this change cannot be accounted for merely by asserting that Wyatt and Surrey were courtiers and aristocrats, and had travelled in France and Spain.

The sixteenth century was also the era of the Protestant Reformation; and, with the interminable controversies on the subject of religion, came also a quickening of the national intelligence, and an extension of the benefits of education.

New aims, new desires, new aspirations, needed once more the inspired voice to give them utterance; and under the Tudor sovereigns came the dawn of that glorious age, which, reaching its apogee under the last of that race, has been called the Elizabethan Period. To this era may be ascribed the birth of the true drama, the offspring of the Moral Plays, and a descendant of the much older Miracle Plays, the last-named dating back to the twelfth century. All through the long reign of Elizabeth the nation was in constant peril from plots at home, and the enmity of Spain abroad, when Spain was to the Englishman of the sixteenth century what Russia is to the Briton of to-day. Gradually England felt its rising strength, and the exploits of the buccaneers on the Spanish Main, the gallant struggle for liberty in the Netherlands, and, above all, the crowning victory over the Armada in the Channel, stirred the soul of the nation to its core, and proved fertile sources of inspiration to the poet, the dramatist, and the prose-writer. To this age belong Marlowe, Shakespeare, Sydney, Spenser, and Bacon,—the mere mention of whose names to the student of English literature is sufficient to mark the influence that this heroic epoch had in the birth and development of genius. Marlow was the dramatist of the period, Spenser the poet, and Bacon the philosopher; but Shakespeare was all these in one, and more.

Of Shakespeare we may say in the words of Hallam: "The name of Shakespeare is the greatest in our literature—it is the greatest in all literature. No man ever came near him in the creative powers of the mind; no man ever had such strength at once, and such variety of imagination."

Like Spenser and Chaucer, Shakespeare's birth and early history are wrapped in obscurity; like Chaucer he towers aloft above his fellows; yet he, too, had his forerunners, and in each of the arts in which he excelled he had his rivals among contemporaries. This was not the age of the courtly gallant; but out of the solid Saxon basis on which the nation was founded sprang the "Poor Scholars" such as Nash, Peile, Greene, and Marlowe. Well educated, and with expensive tastes, which they were debarred from exercising by their poverty, they placed no limit on their satires, having nothing to lose but their lives. Their time was spent in rioting, drunkenness, and debauchery; but, strange to

say, their poems were often as pure as their lives were worthless. Greene's last words were :

> Time, loosely spent, will not again be won !
> My time is loosely spent—and I undone.

Marlowe's life has been said to consist of "a few daring jests, a brawl, and a fatal stab" ; but his Jew of Malta was the predecessor of Shylock ; his "Edward II" stood as the commencement of that grand series in which are "King John," "Henry VI," and "Richard III." The appearance of Marlowe's "Tamburlaine" on the English stage drove from the boards at once and for ever the boorish farces and colourless imitations of Italian comedy which had preceded it.

Like Chaucer, Shakespeare possessed that *joie de vivre* which seems to be steadily disappearing under the pressure of the mental and bodily dyspepsia of the nineteenth century. Leaving his native city, endowed with a keen wit, a charming facility of expression, and a thorough delight in inspecting as by a search-light the actions and characters of men, he commenced with a light heart his gigantic task.

The "Faerie Queene" had been before an English public for three years, when Shakespeare launched what he calls "the first-fruit of my invention," "Venus and Adonis." The stage had been cleared for him about the same time by the death of his rivals, Greene and Marlowe. From this time onwards his literary activity was incessant. Of the order of his plays we know nothing definite. His earlier works are separated from those of later date through the list published by Francis Meres, in 1598. In all these works breathe the spirit of youth, of success, and of happiness. Shakespeare now enjoyed the patronage of Essex and Pembroke, and the friendship of Southampton. With the death of Essex, and the imprisonment or dispersal of his friends, the spirit of his work changes. Joy and delight in life disappear from "Julius Cæsar, "Hamlet," "Othello," and "Lear." In his prosperous days of ease and affluence, when living a life of calm content at Stratford, he regains his belief in the triumph of good over evil ; and, separated from the turmoils of the great world, he revels in pure poetic fancy in "The Tempest" and in a "Winter's Tale."

The rapid creation of the Elizabethan dramatic stage is one of the most astonishing of the literary phenomena of the time ; and when Shakespeare died he left behind him a line of worthy successors in Jonson, Webster, Ford, Massinger, Beaumont, and Fletcher ; but while Shakespeare was the exponent of his age these became more and more the voices of a party, cut off from the mass of the nation by that cleavage which led to the war of 1642–9.

Discontent came in with the Stuarts, and the volcanic upheavals of civil war choked the stream of genius, which had flowed so freely in the sixteenth century, and overflowed into the seventeenth century. With Cromwell there was a short period of peace and prosperity, during which England made herself respected abroad; and from the ranks of the Puritans came two of England's greatest worthies, Milton and Bunyan; the former was the great exponent of English epic poetry; while the latter, being born out of due season, wrote his masterpiece of English religious prose in the licentious times of a Stuart tyrant, within the walls of a prison. Milton was educated at Cambridge, where he received the highest education that England could afford. This he perfected by travel; and, like Chaucer and Surrey, found in Italian poetry that delight and attraction which led him, English-like, to try to excel it in his native tongue. It had always been his ambition to accomplish some great and lasting work. In his treatise on Church Government he says: "By labour and intense study, which I take to be my portion in this life, joined with the strong propensity of nature, I hope to leave something so written to aftertimes as they should not willingly let it die." In the days of his youth and strength, Milton impresses us more as the political and religious controversialist than as the poet of his age; but when tried and purified by a long succession of misfortunes, including blindness, political persecution, and filial neglect, he produced his masterpiece "Paradise Lost." In the folio edition of *Paradise Lost*, published by subscription in 1680, under Milton's portrait appeared the the famous lines of Dryden :—

> Three poets, in three distant ages born,
> Greece, Italy, and England did adorn.
> The first in loftiness of thought surpassed;
> The next in majesty; in both the last,
> The force of Nature could no further go—
> To make a third she joined the former two.

It is a fact worth recording that Milton had access to a copy of Caedmon's Poems, treating on the Fall of the Rebel Angels, and that many similar passages may be recognised in the two works.

Of this epoch we may say with Macaulay: "Though there were many clever men in England in the latter half of the seventeenth century, there were only two minds which possessed the imaginative faculty in a very eminent degree. One of these minds produced 'Paradise Lost,' the other the 'Pilgrim's Progress.'" Like John Bright, in our own times, Bunyan used the simplest words to express the loftiest thoughts; his meaning was as plain to the rustic as to the student, all long-syllabled technical terms

were avoided, and he proved that in this simple form the English tongue was a perfect vehicle for the highest flights of the imagination. Macaulay, no mean critic, has justly said: "For magnificence, for pathos, for vehement exhortation, for subtle disquisition, for every purpose of the poet, the orator, and the divine, this homely dialect, the dialect of plain working men, was perfectly sufficient."

The accession of William III commenced the long struggle with France, which, after William's death, by the skill and courage of Marlborough, crushed the power of Louis the Fourteenth, and made England the arbiter of Europe. This was "the Augustan Age of French literature, made memorable by the sermons of Bossuet, the devotional works of Fénélon, the cynical maxims of La Rochefoucauld, the tragedies of Racine and Corneille, and the comedies of Molière." This period of victory and exaltation was as fertile in the production of genius as the Elizabethan age; and the times of Queen Anne can boast of Swift, Pope, Addison, and Steele, writers whose models were evidently from the French school. Under the last of the Stuart sovereigns the newspaper began to assume its modern form, mainly through the influence of Defoe. To this period may also be referred many of the stages in the development of the modern novel, afterwards further elaborated by Richardson, Fielding, Smollett, Sterne, and Goldsmith.

The age of Addison was the era of the clubs and coffee-houses. In *Pepys' Diary*, that series of literary photographs, we read of discussions at coffee-houses on music with Purcell the celebrated composer; on a former land connection between England and France with James Moore the mathematician; on the "Religio Medici" of Sir Thomas Brown, Butler's "Hudibras," and Osborne's "Advice to a Son," with Sir George Ascue and others; and on English poetry with Cocker the well-known arithmetician. Pepys is a member of the club to which Lilly the astrologer and Ashmole the antiquary belong; and at the "Crown Tavern" he hobnobs with members of the Royal Society.

In the year 1705 Swift and Addison became intimate friends. In a copy of his "Travels to Italy," Addison wrote: "To Jonathan Swift, the most agreeable companion, the truest friend, and the greatest genius of his age, this work is presented by his most humble servant, the author." This friendship must have required much forbearance on the part of Addison, for Swift's imperiousness, and audacious satire, are well known. Addison's conversation was most charming when confined to a small party, and we can imagine the brilliant flow of wit when this party consisted of Swift, Steele, and Addison—the "triumvirate," as the former termed it.

Of Addison, Swift has said: "That man has virtue enough to give reputation to an age." He was one of the first Englishmen, not a churchman, to rise from the ranks to a first-class political

position, solely by his talents. In an age of political corruption, which tainted men like Marlborough, he maintained his truth, his integrity, his constancy in friendship ; and his whole bearing was marked by a decorum which prevented him from overstepping the bounds that hedge round the gentleman and Christian. With a mind so chastened and regulated, Addison became the most perfect master of English prose, and his conversation is said to have been more brilliant and charming than his writings. "Addison almost created, and wholly perfected, English prose as an instrument for the expression of social thought." Chaucer, in his age, and Shakespeare in Elizabethan times, had represented the genius and character of the English nation in poetry ; but Addison was the first to speak for all that was English in prose. His object in writing is given in the following words :—"It was said of Socrates that he brought down philosophy from heaven to inhabit among men ; and I shall be ambitious to have it said of me that I have brought philosophy out of closets and libraries, schools and colleges, to dwell at clubs and assemblies, at tea-tables, and in coffee-houses." Johnson declares that "whoever wishes to obtain an English style, familiar but not coarse, and elegant but not ostentatious, must give his days and nights to the volumes of Addison." Macaulay terms him "the unsullied statesman, the accomplished scholar, the master of pure English eloquence, the consummate painter of life and manners, the great satirist who alone knew how to use ridicule without abusing it, and who reconciled wit and virtue after a long and disastrous separation, during which wit had been led astray by profligacy, and virtue by fanaticism."

During the Seven Years' War with France and Spain, Johnson and Goldsmith were the pillars of English literature. From this struggle Britain issued with honour, having gained much additional territory and a considerable quantity of treasure. For this period we have Boswell's inimitable "Life of Johnson" to draw upon.

Johnson was an exaggerated type of the Englishman of his day : stout in build, rugged in appearance, blunt in speech, and tempestuous in manner ; beneath all these he concealed a kindly and sensitive heart. Not averse to quarrel, he was readily disarmed by kindness ; and with all the insular prejudices of his age, he was ever on the side of truth, right, and justice.

Among the struggling authors of the day Johnson had always one or more under his wing. In Grub-street he was the friend of Richard Savage, that wayward genius to whom gifts seem to have been given for no other pupose than that they might blast his own life. At a later date he was the friend, adviser, and protector of Goldsmith.

After the appearance of his dictionary, Johnson became the great champion of literature, the ruler of the English literary

world, a meet successor to Ben Jonson, Dryden, and Pope, and the last in England to hold this sceptre unchallenged. Johnson's Court was held at the "Turk's Head," Gerard-street, Soho, where met the celebrated club, of which Reynolds, Burke, Nugent, Beauclerk, Langton, Goldsmith, Chaimier, and Hawkins were the original members. Johnson trained himself for these meetings as an athelete trains his physical frame for the coming struggle. Against each member of the club he pitted himself in turn; and such was his torrent of language, his fertility of resource, his keenness to detect a flaw in argument, and his merciless repartee, that he seldom issued from the conflict with colours lowered.

In contrast with Johnson, Goldsmith was small, mean-looking, pitted with the small-pox, and endowed with a keen sensibility which made his life a constant torment. He was the butt of men wholly his inferiors in genius, by whom he was regarded as an inspired madman; and who repaid his nervous attempts at conversational wit with shrieks of laughter and cruel practical jokes; but, pen in hand, he was the master of them all, Johnson included.

Of the treatment accorded to this man of genius, who was poet, dramatist, and novelist at the same time, Thackeray writes: "The insults to which he had to submit are shocking to read of—slander, contumely, vulgar satire, brutal malignity, perverting his commonest motives and actions; he had his share of these, and one's anger is roused at reading of them as it is at seeing a woman insulted, or a child assaulted—at the notion that a creature so very gentle and weak, and full of love, should have had to suffer so."

During the reigns of the Georges, with much that was sordid and venal, there were many national rejoicings over such events as the total surrender of France in America and India, the noble deeds of Nelson and his brother seamen, and the crowning victory of Wellington at Waterloo. The pride and fervour and exaltation engendered by these successful enterprises again proved fertile sources of genius, and the nineteenth century ushered in the rich literary harvest of the Georgian era. The poets of the so-called Lake School broke through the artificial trammels that beset English poetry, and, under the influence of German writers, proved that familiar and lowly subjects are fit themes for the greatest talents. Another poet and novelist, whose inspiration came with this heroic age, was also under the influence of the German school, but never as a mere imitator or copyist. Scott's poems are lays and romances of chivalry—a national edition with jewelled setting of the ballad poetry of his country. His prose works have done more than those of any other writer to unite, under the influence of a common patriotism, the Celt, Saxon, and Norse elements of Scotland. Other poets of the Georgian era are Byron, Shelley, and Keats, all of whom died young. Byron and Shelley by

their long residence on the Continent, were much influenced by the literature of the Latin nations; and Byron is probably better appreciated in France and Italy than in England. All these writers were under the spell of the French Revolution, and the fire and fervour which glow in their stories of battle and passion were but reflections from the volcanic outburst across the Channel.

The main feature of the Victorian era is the absence of any one predominating style either in prose or poetry; on the contrary, many styles may be selected, each strongly marked in its characteristics, and excellent of its kind, yet differing from all others in a striking degree. Few of the Victorian writers speak for the nation as a whole. Tennyson is the poet of the well-educated classes, and Thackeray is their novel writer; Dickens is the exponent of city life, speaking for the millions of London; Charlotte Brontë gives her impressions of Northumbrian life, true from the Peak to the Tweed; Carlyle stands solitary and aloof, an old Norse rock not yet buried under the softer strata of Celt and Saxon; Charles Kingsley represents south-western England, the birth-place of Elizabethan seamen, the home of the gentlemen adventurers, and the cradle of the Glorious Revolution of 1689. Trollope, like Thackeray, restricts himself mainly to people who sit above the salt; George Eliot had an artistic soul and a critical mastery over the English language, but her productions, especially the latter ones, are forced and laboured, and have nothing representing the smooth unconscious flow of the selected one who speaks with the voice of national inspiration.

Carlyle, by choosing to convey his thoughts to the world in what can only be regarded as a dialect, cut himself off from all but a chosen and cultured section of his fellow-countrymen. Among Victorian writers Macaulay most sharply contrasts with Carlyle. He is the man of the world—the great optimist, the champion of things as they are. His lays, essays, and history are known throughout the English-speaking world; and, though the critics have denounced them, and find them full of literary faults, they have never been able to shake the national love for his works, or the delight of the millions in their perusal. It has been said by Mr. Chamberlain that, though his countrymen may be mistaken in matters of political detail, they are invariably correct in their judgment of the main issues; and I believe this is as true of literature as it is of politics.

Disraeli has shown us what a powerful weapon may be made of the novel in politics. With his three novels, Coningsby, Sybil, and Tancred, he crushed the Whig party, rehabilitated the Tories on their present basis, and rallied the forces of the English Church and of British Imperialism, to the assistance of modern Conservatism. Disraeli's works are the only instances in English literature

of a statesman of the first rank disburdening himself to his fellow-countrymen by means of fiction—of satirical fiction.

In Thackeray we have one of the finest masters of English prose since the days of Addison; and his English is equally perfect in all his works, from the earliest production to the last volume. In parody of all kinds he excelled, and his "Novels by Eminent Hands," are of real service to the literary critic, but are apt to lead the novice to over-estimate the faults parodied. Another of his gifts was the power of imitation, wonderfully exhibited in the letters attributed to his characters. Usually we feel inclined to skip the letters in a novel, but letters penned by Thackeray for his characters are always read with pleasure. With all his geniality in private life, Thackeray's writings would make one regard him as an embittered cynic, gloating over the falseness and snobbery and hypocrisy of the world.

It has been said of him by a living critic: "If we run over the characters of Shakespeare, or of Scott, we have to reflect before we find the villains. If we run over the characters in Thackeray, it is an effort of memory to recall the generous and the fine natures."

The great humorist of the Victorian age is Charles Dickens; but his humour, like Cruickshank's sketches, depends mainly on caricature; and like Punch with his nose and his hump, each of Dickens's characters has his sign or shibboleth by which he is recognised. Artificial as this may seem, we know that he studied his characters with the most minute care; and, by skilful touches here and there, threw their peculiarities into more striking relief. Like Chaucer and Shakespeare he had a most wonderful fund of gaiety and vitality; his energy was immense, and hilarity and drollery run like twin veins of gold through all his works.

In his mastery over English prose, and in his wit and character-building, Trollope is much inferior to Thackeray; yet a certain comparison is possible. There is the same undeviating standard of merit through all his composition—the same smooth easy flow of language, and the same exactitude of expression. There is a plentiful supply of natural conversation, and an utter absence of all that is obscure, oracular, or enigmatic.

Harrison states respecting Trollope, that: "From the first line to the last there is never a sentence or a passage which strikes a discordant note; we are never worried by a spasmodic phrase, nor bored by fine writing that fails to come off." It is a curious fact that Trollope had little opportunity in early life for the study of the clerical and aristocratic characters that fill his pages, and whom he depicts with such a master hand.

George Eliot, like our own Rolfe Boldrewood, was a writer of slow development, publishing her first tale when nearly 40 years of age. She was a woman of the highest culture, richly stored

with knowledge, and with a most artistic nature; but not a born novelist. She elaborated with painful slowness, and never possessed that self-confidence which marks writers like Trollope and Thackeray. For these reasons she failed most completely as a poet. The English of her poems is faultless; her lines are chiselled and polished, and the phrases are perfect; but the soul itself is wanting. The most ennobling feature in her work is the spirit of responsibility in which she wrote, recognising that a writer of eminence holds a position of authority in trust for the nation.

Another peculiar feature of the era is the widening of the literary field. Rider Haggard has done more to make South Africa known than all the geographers of the age; Gilbert Parker is performing a similar work for Canada, writing as the friend and admirer of both English and French-Canadians; Kipling has taken India as his province, and has lately so extended his range as to be hailed as the Poet Laureate of the Empire.

There seem to be two forces at work in the present day, both tending to check the production of literary genius. One lies in the wonderful progress of science, and the rewards it offers to its votaries; the other arises from the universal education now dispensed throughout the English-speaking nations. We have it from Darwin himself, that a life spent in the pursuit of science deadens artistic aspirations, and tends to make invention and research the only pleasures.

In the time of Addison the writer had to face the critics of the Clubs and Coffee-houses; in Byron's day his fame must withstand the onslaught of the writers of the critical reviews; but in the present age the whole nation criticises, and literary factions belaud or berate each literary aspirant. A man of Goldsmith's exquisite sensibility, who talked ridiculously under fear of his comrades' coarse satire, yet wrote divinely when free and untrammelled in his own chamber, would probably have allowed his genius to die fruitless, rather than face the criticisms of an educated nation. No one now dare lay bare the heart as Charlotte Brontë did in "Jane Eyre," or paint his friends with all their blemishes as did Boswell in his "Life of Johnson." Such writers would now be covered with ridicule.

Under the twin influences of compulsory education and scientific invention, the Britain of to-day is no longer the field of romance it was to Defoe, Fielding, and Goldsmith. The bicycle, the railway-car, the newspaper, the telegraph, the better level of comfort, have banished romance to India, to the wilds of Africa, to the snows of Canada, to the shores of the Pacific.

With the education of the labourer and artisan came a clearer conception of their position of inferiority in the world, and the many disadvantages inherent to that position. A period of social unrest set in, carrying with it a vague feeling of alarm to

some, a premonition of coming change to others. With its strikes and combinations, its fierce party quarrels, its desire for change, it recalled in a mild way the state of France before the Revolution,

This great socialistic movement has curiously affected all recent literature. Whoever has a mission now, makes use of fiction to preach his creed, to advance his party, to defeat his opponents. It seems as if the pulpit has lost its power, and literature has usurped its place. Novels like "Tom Jones" and "The Vicar of Wakefield" are now unknown. This is the age of subjective novels, of novels political, novels religious, novels scientific,—all novels with a purpose—disguised and lengthened sermons.

Literature is seldom now a profession in itself. It is looked upon as a means to an end—a weapon to be employed in various forms of propaganda—religious, social, political. There is now no living English poet or English novelist of the first class—each speaks for a purpose, a party, a fraction of a party, a narrow field; no one is commissioned from the nation at large.

If there has been a time during the last thirty years when the minds of Englishmen were in accord, and when their voices expressed the greatest unanimity, it was during the late period of storm and stress, when Germany, a supposed friend and blood relation, took advantage of our difficulties to do us an unfriendly act; yet the situation evoked nothing better than Austin's pitiful poem—a possible sign that the inspiration which was created by the victorious issue of the long continued struggle with Napoleon has spent itself, and literary decadence has set in.

No. 1.—THE RELATION OF ETHICS TO POLITICAL ECONOMY.

By the Rev. Thos. Roseby, M.A., LL.D., F.R.A.S.

(*Read Friday, January* 7, 1898.)

No. 2.—THE ETHICAL ELEMENT IN EDUCATION.

By the Rev. Geo. Littlemore.

(*Read Friday, January* 7, 1898.)

No. 3.—ENGLISH THEORIES OF INDIVIDUAL FREEDOM.

By the Rev. Jas. Hill, M.A.

(*Read Saturday, January* 8, 1898.)

No. 4.—IDEALISM IN ETHICS AND RELIGION.

By the Rev. A. J. Griffith, M.A.

(*Read Saturday, January* 8, 1898.)

No. 5.—THE PSYCHOLOGY OF ATTENTION.

By the Rev. N. J. Cocks, M.A.

(*Read Monday, January* 10, 1898.)

There are at the present day an old and a new Psychology existing side by side.

Once there were an old and a new Astronomy, but the new took up the old and both became one—a Science in which the ancient observation of Fact is combined with the modern conception of Law.

The time has not yet arrived for a similar development in the science of Mind.

The methods of experience and analysis will continue for a while to appear antagonistic to each other.

The biologist who comes with experiment and searching inquiry will still believe he is on a different quest from the philosopher who arranges old facts and uses an antique phraseology ; but the two will meet some day, and will find they have really been bent towards the same point, though from opposite directions.

Without any claim to special insight, it may be predicted that the field of their common observation will lead to this ultimate unity. There is always that in the world we look out upon which draws the mind irresistibly to surpass its own earlier attainment.

Since, then, Psychology is in this stage, the value of the present inquiry will be obvious. The great need for those who follow either the old or the new method is to ascertain clearly and fully the nature and scope of their subject matter ; for the activity of Thought is itself the inspiration of renewed research, and in the multitude of phenomena is hidden their final Law.

Our attempt will be, therefore, to survey and arrange the facts of this subject of Attention.

What Attention is most people pretty well understand, and to define the familiar is often to veil the known with the obscure—to clothe Apollo.

Still the limits of the subject must be stated, and some picture or illustration of it may not be out of place.

By Attention, then, will be meant,—sustained perception, leading to the grasp of new relations in the object under view.

An example that brings out this meaning may be found in the way a chemist deals with an apparently new specimen. First, he

examines it very carefully to determine whether it is new to him or not. Amongst the ordered system of his own chemical experience he seeks a place which it may fill and to which it may thus belong.

Then, when he has realised its strangeness, he brings the agents of analysis which reduce the specimen to elements easy to recognise.

All the time his mind has been intent on the one end—to bring this new object into true relation with the rest of his knowledge; and generally this attempt may be taken as a type of Attention.

It cannot, of course, be expected that all the examples which enter into this survey will show their true character as plainly as does this typical instance.

To get a complete view of any subject one must begin with forms that are elementary, and trace the line of development. So here a commencement must be made with the unconscious perception of childhood, and several cases must be dealt with that seem somewhat unimportant.

It will be found, however, that the order of growth affords a capital means of classification. Corresponding to the three stages of childhood, youth, and maturity, there are three classes of Attention, caused in turn by the Attraction of the Object, by Control imposed from without, and by Will exercised from within.

Still, even with such a scheme of the subject it is impossible to embrace every variety, and there are certain forms which commonly occur that may be noticed apart.

There is a class of experiences in which is exhibited the most intent application, that are brought about by feeling, and which lead to very little intellectual result.

Hunger makes a cat watch for a mouse; fear causes a man who has lost his way to look anxiously for the road; yet the real attention in such instances is wholly subordinated to desire. The knowledge of new relations gained in such mental activity is very little. The effort made by the mind seems rather an attempt to grasp a laggard experience than to perceive fact or truth.

There is another similar class of phenomena, of a more striking character, which falls under the same judgment. Sometimes when one is under the influence of strong and deep emotion, the features of a scene become impressed upon his mind with an extraordinary vividness. He can "see" the locality years afterwards, whenever circumstances may awaken the memory of his joy or sorrow.

Yet the perception which brings about such a remarkable result holds but a secondary place to the emotion. It may be called an harmonic in the experience, hardly recognised at first as a distinct tone, but gradually gaining in clearness and independent value. Therefore, although its effect may be so striking, such semi-unconscious and subordinate attention in itself, possesses no qualities specially calling for notice.

There is, perhaps, one other set of facts akin to the subject that should be recognised before the field itself is entered. The concentration of mind which induces the hypnotic state is sometimes taken for true Attention. That such an estimate is an error becomes at once apparent when the difference of result is noted. In this experience the object contemplated becomes less—not greater or richer—in relatedness. The mind does not grow into knowledge ; it becomes reduced to unconsciousness. The continued perception is of a bare act only, not of an activity.

No more conspicuous example of failure in what is most essential to Attention could be found than this seemingly perfect mental concentration.

There will be no need to look further into border regions of the subject. Additional instances of its occurrence in extraordinary conditions may be found outside the limit of each division ; but the continent itself has now to be explored.

The beginning of true Attention is to be found in a stage of mental life that lies below self-consciousness. The prolonged gaze of an infant at any bright object, the interest displayed by a young child in the very movement of Nature around, indicate the rising up of intelligence to the comprehension of the visible world.

The value of these acts of perception, other than the purity and beauty which belong inseparably to young life of a noble order, is merely prophetic. The gain they bring of knowledge, which is itself the entering in of the world of reality, so soon is lost like a bud in the blossom ; but they do indicate in a very striking fashion the nature and the history of Attention.

The sustained activity of Mind is caused at first by the attraction of Nature. The world which to vision is all of light, appeals primarily by its brightest objects. In a new country one invariably lifts up his eyes to the hills ; then a continuance of changes like the rhythmic rising and falling of music, wins and holds the mind, until gradually it is found the relations of fact have become established as thought.

This first stage of Attention is not confined however to the time of infancy ; neither is its perception limited to natural objects. All learning that is said to be by intuition, or that comes from the observation of example, is also of this order, though it be continued far on into life. There are those who pick up some knowledge of Art, Business, Science, as a little child learns colour.

Such perception by special inherited faculty, won and held by the attraction of the object, is called often "the insight of genius." Or it is said to be, in more extraordinary cases, as of the calculating boy, Inandi, the exercise of a mysterious gift.

Yet it is to be noted the gift or faculty is only half the secret of the phenomenon. There is in the object or truth contemplated a fascination like that which is exerted by light upon the power of vision. These also are instances of the Attention of Attraction.

Here then, may the subject be seen at its purest, and in many respects in its most attractive form.

Into the activity other mental elements, as yet, do not enter. There is no necessity for Will ; there is no inclination to look for reward. Certainly there is pleasure, and, in the highest cases, joy ; but these are not separable from the energy with which they are associated. The consciousness of mental activity invariably has pleasure for its beginning. The Attention that is won by Attraction is the direct unhesitating response of Mind to Nature to Truth ; and as it is at the beginning of life, so does it continue to be the human condition of entering into a living universe, that does not grow bare before knowledge, but ever expands into newer and higher relations.

The second phase of the subject presents in many ways a complete contrast to this simple natural activity. The mind has now to be directed towards objects of little or no primary interest ; its energy has to be maintained and controlled by external influence.

The most perfect examples of this period, through which every intelligence must pass, are to be found in the experience of children or youths who are under the guidance of a teacher. The subjects of their study are provided, the methods to be followed are laid down, the inducements to progress are set forth, by those who have the care of their education.

At first sight it might seem as though there were so many outside influences at work that the attention gained was really subordinate,—like that, in fact, employed by desire or fear ; but it will easily be seen that all the teacher's aim is accessory to the Attention —the sustained mental effort of the scholar is the true end of education.

Moreover, a little examination shows that the relation of teacher to scholar is not accidental or formal, but essential, and of the highest importance ; for it is the work of the teacher that supplies elements which make attention possible : he must invest the subject with a charm it does not at first possess ; he must strengthen the incipient purpose of the learner.

Thus it may be seen how this division of Attention stands midway between the other two, and is connected with them. Here by human means, objects are made to copy Nature in grace and interest, and young minds are led to effort that is the imitation of high pure purpose.

These two sides of the function of education may be taken as the chief conditions of this stage of the subject, and as such cannot be too clearly stated.

It is the movement of Nature, as well as her eternal persistence, that wins a child's early regard; it is her endless variety that draws the mind forth in spontaneous, delighted perception.

The first task of the teacher is, then, to show the material he presents is not dull and dead. When the matter of a subject is proved to be itself motion, then the activity of the mind arises in unison with it.

Examples of failure in study, arising from the inertness of the subject as it is presented, are common-place incidents of every experience. The writer was acquainted with a young business man who was seized with a strong desire to read Theology. The books obtained for the purpose were old-fashioned in expression, and altogether dull. The consequence was, that after a very few minutes reading he invariably went to sleep. In spite of a strong exercise of will, and a specially contrived uncomfortable chair, the same result continued to be manifested, until at last he gave up, believing he was without capacity.

The truth of the matter was, however, the material of the book was so dead to him, his mental gaze could perceive no movement; and like a man looking intently at a button, he fell almost into a mesmeric condition.

The absolute necessity for art in presenting a subject with a life and grace of its own can want no stronger proof than the dulness and poverty of mind brought on by inadequate teaching. Loss, and even suffering, must result if the attraction of Nature be followed in a child's experience by dull inept instruction.

The second condition for the exercise of this attention—that the energy of the scholar shall be maintained by the teacher—is just as important, practically and theoretically.

Sometimes purpose can be aroused by the fear of punishment or the prospect of a reward. A dull but ambitious boy can, by the promise of a prize, be excited to continuous and successful effort; indeed the progress of most of our primary and secondary schools depends largely on such an appeal to the love of distinction. Our Universities are not without it, and it enters into the highest fields of private duty and public service.

There is, however, a method, if such it can be called, which leads to the result aimed at in a far nobler way. A companionship in study or research between teacher and scholar is the highest and most unfailing inspiration to purpose. When attention is developed by external device or hope of reward, it is apt to fail as soon as the restraint is removed or the prize attained; but when personal comradeship in effort has afforded the stimulus to industry, an ideal is gained that may retain its power through a life-time.

An example of teaching, in which both of these conditions are fulfilled, simply, may be found in those modern schools for very young children called kindergarten. There truth is made to wear any fantastic dress that can make it attractive ; while the teacher becomes as much one with the juveniles as possible. The whole aim is to copy Nature in matter, and the home in manner of teaching.

With more encouragement of the necessary exercise of will for those of rather older growth, this system may be taken to exemplify the second stage of attention, in which the mental activity is aroused and controlled by external intellectual agency.

Before passing to the third division of the subject, there is an interesting fact which may be noticed as showing a transition towards this independent voluntary exercise of the mind.

At those schools in England where boys attend for half-time and spend the rest of the day at work, it is found that on the whole the half-time boys do as well as those who spend the full day at school. The powers of will and concentration learned under the discipline of the factory, as well as the conception of the value of education gained from outside, render the attention of these lads more strong and consistent than it would be otherwise.

This fact provides a ready introduction to the special characteristic of this third kind of Attention—that is, the purpose which enables a man, independent of other considerations, to devote his mind to the pursuit of knowledge.

Concerning this exercise of will, which maintains perception as a force from within, it may be noticed, in comparison with the other determining influences, it is peculiarly a function of mind in its maturity. The Attention which at first is called by Nature, then guided to fact, is, if it attains its full strength, at last self-directed towards Truth.

Still, while these differences are marked, it must not be overlooked that this highest stage, as in all developments, contains the others. The object contemplated possesses a fascination for thought; self-restraint or quickening must frequently be exercised; childhood and youth are merged, not lost in manhood.

The introduction of Will tends also to make the attention more of a unity than before ; and although it is necessary to divide the full mental energy into sections for the sake of observation, one part cannot take the pre-eminence as attraction and education have done earlier. Alongside of the controlling force must be seen the scope of perception, and the necessary accompaniments of attention in the mind. In this free, high, intellectual activity no one side can be taken as characteristic ; it shows itself only when viewed as a whole. It will be necessary, therefore, to survey the three sections just mentioned of Will, Object, and Harmonic, in order.

The function of Will, in relation to attention, is commonly known as abstraction. In the countless calls that come for interest and inquiry, selection must first be made ; then, after the choice has been taken, serious interference with the mind's occupation has to be guarded against. The service thus rendered by abstraction seems to be of a preventive or negative character ; but it is manifestly unfair to regard it apart from the positive vision with which it is associated, and to stigmatise it as bare and unfruitful. Sometimes choice may be made of an unworthy object ; then the abstraction of purpose is judged speedily, and condemned as being exclusive of good, and leading to a vain result. At another time, however, when a great theme occupies the mind, the negative abstraction is lost sight of in the splendid thought it serves to protect.

It may be said that Will, to a great extent, takes the place of the teacher noticed above ; and, of course, if the object regarded voluntarily be like the dry subject of insufficient interest or value, the result also will be like that described.

There is a graphic account given by a champion cyclist of his experiences while following pace, that illustrates abstraction. "After riding a little time," he says, "the people around the course gradually became indistinct, and their applause sounded far away ; then the colour of the track and the grass was lost, and the rush of the air became less perceptible, until at last, in the intensity of his effort to pick up the pacing machines, the daylight almost entirely faded away from him, and all the varied sounds of the course sank into a confused roar."

The chronicling of this experience produced in the minds of many who read it a feeling almost of horror at the effect narrated. The end sought is so palpably inadequate to the loss of sight and sound it involves.

Should anyone, however, who is accustomed to close mental application, compare what is here set down with what he himself has felt in the course of his work, he will recognise, by the similarity of the result, an abstraction identical in itself with his own. For him, in his writing or experiment, the world gradually becomes far away, and indistinct ; he is not conscious of sunshine or shade ; the voices of friends are mere sounds, indefinite and unheeded.

The abstraction involved in attention then beyond its power of persistence, takes all its quality, its value, from the object of scrutiny. It may be bare and conspicuous ; it may be hidden in a rich world of idea. Everything as to its character depends on that to which the mind is directed. The example of Newton will, perhaps, serve to show to how noble a height this controlling purpose may attain.

In describing the method he adopts to reach his discoveries, he said he kept the subject always before him, sometimes for long

periods, until at last the light shining forth made dawn in his own mind.

When it is remembered that dawn in the mind of a Newton means the beginning of a new day of knowledge for mankind, the ultimate value of his abstraction becomes still more clearly manifest.

From what has been observed already concerning the field or scope of attention, it is easy to pass to its consideration. The mind may be directed to any object of any interest, if this can but furnish a new relation for perception. The three co-existent worlds of Nature, Humanity, Mind, each infinite in extent or complexity, offer subjects, it would seem, to suffice eternity.

As, therefore, it is not possible to indicate in more than this general way the full scope of knowledge, it would be useless to catalogue its material in detail. A word may not be out of place, however, as to its limits, for there are bounds set beyond which it may not pass.

On the one side, an object must be capable of opening out before thought if it is to be regarded with attention; on the other, for the Mind to attain to a vision of Truth uncomprehended before, there must be steps by which it may climb—a highway prepared in the desert.

Sufficient, perhaps, has been said with regard to any attempt to transgress the lower of these limits, the effort at Attention simply becomes nullified; but with regard to the higher, a glance at its meaning is needed.

There is really no region of human experience that can be considered necessarily closed to the view of Attention. Prejudice and timidity combine often to prevent this steady, earnest, application to subjects of paramount interest and importance. The whole fields of the mental, moral, and spiritual have hardly yet been opened to the vision which alone finds enduring ordered knowledge.

It cannot, however, be supposed that such alien motives will always maintain their influence. The time must come when Attention, step by step, will penetrate to the very centre of these lands now so strange and so fascinating in their mystery.

The scope of Attention is therefore far wider than is popularly supposed; its function to deal with matters quite beyond the passing fashion of interest.

Still the practical attainment of this activity depends absolutely on the condition just recognised. Knowledge of relations is only to be gained step by step. Upon the achievment of the past the seer must stand who would look into the future. Copernicus, Galileo, Kepler, Newton, follow in an order invariable as necessity.

It must be, then, that for a long time in every department of experience, Attention must follow feeling and belief slowly, and

sometimes at a great distance; but she passes from fact to fact that have been established for ever, until at last she comes to the ultimate law or spirit which has inspired the earlier faith and emotion.

The whole task of Attention, may be likened to that of the Astronomer who attempts to sound the star depths. In method and field her undertaking is strikingly similar; her success must be as tentative and as gradually achieved.

The Harmonics of Attention, with a reference to which this sketch is to close, are naturally as wide and varied as experience.

The mental effort required to maintain the perception itself induces subordinate feelings of anxiety, hope, pleasure. The object upon which the mind is concentrated awakens memories by association that may be almost as full and fresh as new enjoyment.

It will be necessary, therefore, again to denote the richness of this part of the subject rather by boundary lines than by its substance or colour.

A remarkable instance is given in the life of Tennyson lately published of a high mental experience accompanying a certain act of Attention.

The Poet was able, it is said, by concentrating his thought entirely on his own name to rise into a state of exaltation in which all his noblest nature seemed to be alive and active.

It is evident that such a result could not be attained by direct effort. The mind was turned to the ideal of self, denoted by the name, and the whole being awoke in unison with the activity of Attention.

It might be shown that important results occur in the development of character, as secondary effects of devoting thought to worthy objects. The quality of the emotion or subordinate purpose very largely depends on the question occupying Attention.

Again, as a matter practically involved in teaching, it might be pointed out that some of the phenomena which appear to denote inattention are often the necessary accompaniments of the mind's action.

A boy has come under the writer's notice who seems incapable of receiving the instruction imparted unless he can keep his hands employed in some trivial occupation. If he looks intently at the teacher he apparently hears little or nothing that is said; but if he is allowed to play as he likes in a quiet way he is the smartest boy in the school.

These incidents may, perhaps, serve to mark off this division of the subject, though, of course, they can but suggest in a bare fashion the wealth of its detail; and as leading out away from Attention proper to that which is always involved in its activity, they may also serve as a limit for the present survey.

No. 6—THE PLACE OF MUSEUMS IN UNIVERSITY EDUCATION.

By Miss L. Macdonald, M.A.

(*Read Monday, January* 10, 1898.)

No. 7—THE PERMANENT PLACE OF LITERATURE IN EDUCATION.

By Rev. C. J. Prescott, M.A.

(*Read Monday, January* 10, 1898).

No. 8—THE FUNCTION OF CLASSICAL STUDY IN EDUCATION.

By F. V. Pratt, M.A.

(*Read Monday, January* 10, 1898.)

No. 9.—FACT AND IDEA.

By C. J. Brennan, M.A.

(*Read Tuesday, January* 11, 1898.)

§ Cogitatur is the most comprehensive statement of the Universe.

The ordinary view of the world, which every man daily makes use of and assumes, may be shortly expressed thus: space-occupying bodies whereof one is mine, on the one hand; on the other, awareness of these bodies and various feelings in relation to them, this awareness and these feelings forming a unity of consciousness, mine. The last concept of this phase of consciousness, the final statement of this view, is the separation of the whole into two *divisibilia*, two disparates—Matter and Mind; whereupon, the old metaphysical scruple—How came this world here?—insinuates itself under this form: How then can one disparate know the other?

From the point of view just analysed, no answer can be given; the question can merely be stated. Deeper analysis removes the scruple altogether, seeing that the view of the world from which

it arises is not final, secondly that it is a division; for not merely does it make a crude distinction between phenomena merely according to the category of space, but it sets asunder what it found united. How shall they be again united, unless we first abandon our arbitrary division? For a knowing subject, the final view of things must be based on knowledge. However true it may be that, taking space as basis of our analysis, knower is here and known is there, distinct and divisible; from the standpoint of knowledge, knower and known are united, distinct but indivisible, mutually necessary and inseparable. Everything objective has its subjective aspect; every thing is also a feeling; otherwise, for knowledge, it would not exist. And it is for knowledge, for consciousness, that we analyse.

The phase of consciousness which yields us subject and object as inseparable aspects of the one phenomenon is technically known as Reflection. *Cogitatur—it is known, it thinks*—we have no impersonal verb of the kind—is its expression; and observe, nothing more is necessary. For *cogito, I think*, merely expresses the unity and continuity in time of the subjective aspect, which, along with its objective aspect, becomes object in Reflection, and, at the same time, its separation from the object. This mode of consciousness—direct, as it is called—must justify itself by reflective. In reflection there is no self-consciousness; but reflection is the basis of self-consciousness. Preceding reflection there is a mode of consciousness—primary, as we observe it in the child—wherein the subjective aspect has not yet become object; but reflection has not to justify itself by this mode, seeing that it alone makes explicit what was implicit in the latter—makes real its potentiality; whereas the division and separation performed by direct consciousness presupposes and assumes the distinction performed by reflection.

Reflection is the decisive mode of all consciousness.

§ The world in primary consciousness is one, and everything given therein is real. Reflection shows the ground of this reality, in that the real is given, but given in consciousness.

There is, however, another kind of question as to reality, which arises in direct consciousness—another form of the old metaphysical scruple, Cartesian doubt. It begins and ends in direct consciousness: its last word is *cogito*, *I* as object to *myself* cannot be other than real; but these other things. . . ?

But these other things *are* given in consciousness! Even a sense-hallucination is a reality, as such; reflection cannot shake it. Its rejection is the result of a judgment, delivered according to the evidence of full consciousness directed by attention; its persistence or non-persistence for full consciousness determines its secondary reality or unreality.

Here we reach the question—How certain things can be *more* real to consciousness, apart from their reality to mere awareness, or reflection, in answer to *what demands* they are more real? Simply, the human procedure with regard to reality. Why do we choose and reject—on what authority?

Is it not plain that the authority must lie in consciousness, be other than mere awareness (Wahrnehmung)?

Consider a moment our judgment with regard to error—hallucination. Reality—on what else does it depend except on our awareness, on its presence in our consciousness? Not on its duration in our consciousness; for how many fleeting things do we hold for real? and how indeed can five minutes more or less affect reality where duration is infinite? We simply reverse the verdict of plain consciousness.

Have we not here an indication that man shapes his reality for himself out of some indifferent *brutum*? Do we not find reason to suspect that he is led thereto by his longing for stability?

The existence of error in the world is indeed a suggestive question. Why error? Is it that reality depends on man and his search for it? Or is it that the unreal, the misleading, the erroneous, which we gradually set aside, are the only actual world; that man never comes into touch with the true reality; that he must seek another real—or another error—which will better suit him—his interests?

§ Yes, the human procedure is a modification of reality—say, rather, a substitution of humanity for reality.

The Fact is not the object alone—to make the mere object the fact is already a human process—and contains not merely feeling as awareness, but feeling as emotion; for an emotion is the subjective aspect of the object, and there is no object in the universe which does not excite, invariably, some emotion. The fact is one: we break it up.

The first action of direct consciousness is to separate consciousness, and more particularly emotion, from its object; and our everyday habit is to look upon this latter residue as the fact, whilst ignoring the subjective side, and, above all, never dreaming that the emotions form an indispensable aspect of the phenomenon. Perhaps, in this, we are belying the motive which led to the separation of Mind and Matter as empirical objects: which separation, following the discovery of Feeling in reflection, was surely no homage to the solidity of the outer world—rather, say, the pulling of itself together by consciousness in face of the object: whereupon follows the ordinary world-view, since consciousness finds itself united to a body which is to it a matter of great interest.

Otherwise, why this division of the world into Matter and Mind? Was there not many another possible line of section?

Or otherwise: since all things are in the primary sense real, and since consciousness is the test of this reality, why, in establishing this secondary distinction of real and unreal, of which consciousness is the sole arbiter, ignore a certain part of consciousness, because of its apparent disconnection with the material objects which occupy space? Are we not, in making this conception our basis of reality, granting everything to a set of interests, pressing, in regard to this body which belongs to us? Logical reason for such standpoint there is none: interest is the key of the situation.

Standpoints—from many such do we deal with the world after our separation of its subjective and objective aspects. Each point of view is arbitrary: it is the strategic position of a certain interest—is not Occam's famous razor merely the expression of a mental need for clearness?—directing the attention towards its object. Attention directed by interest—that is, the force which sets in motion the whole machinery of human thought and endeavour.

As has been said, we break up the fact. We abstract the subjective aspect; the objective remains poorer. We further break up our *abstracta*, according to each varying interest. Do we not thereby limit the range of our possible conclusions? Whereupon I ask: Is this not merely the necessary πρόδρομος to some further reunion, determined by the unity of interests? Is it not the search after another, fuller Fact? That we must so proceed with the world as we do, shows—that it does not recognise our interests: the objective world is fixed and firm; they not. Are we not aiming at a transformation of it, wherein their importance shall be as absolute a fact as the existence of this sheet of paper?

The question brings to light a certain human doubt,—*Am I*... ? We shall recur to it later on.

§ The procedure of the abstract intellect, by its very simplicity, is a good example of the way in which man remoulds reality in answer to his interests.

The starting-point of the intellect is the concept. The form of the intellect is the same as that of perception: the concept is formed out of reality, but rejects all phases of the latter which are not required for the satisfaction of the interest in question. Thus, for several phases of reality, meeting in various ways in different objects, we have a set of concepts, formed by the attention singling out each phase from all the objects in which it occurs. The unity of the object, already detached from the unity of Fact, is broken up according to the variety of interests, whose unity is

that of consciousness. And it is this unity of consciousness, whose form is infinite duration, that gives the final unity and justification to all our voluntary modification of the world—intellectual, moral, æsthetic.

The modification is equivalent to a recreation.

One procedure—that of the intellect with regard to spatial perception, otherwise material bodies—demands, at the present moment, attention.

The bodies are regarded as apart from all human feeling; and their properties are measured by certain standards of space and time—standards absolute only in so far as they are purely arbitrary.

They being converted into concepts, the concepts of their interaction (otherwise laws) are sought, with this aim—to reduce them to a unity: an ideal, is it not?

Observing certain interactions of complete empirical bodies, the intellect extends these laws into the infinite, transforming, ideally, those aspects of bodies which are the objects of the visual, auditory, olfactory, caloric senses into results of the object of our crudest sense—that which contains for us the most interest from the point of view of ourselves as space-occupying bodies—Touch.

Time was, when this transformation was attempted from another standpoint; but the strongest interest in this domain of space-occupying bodies has, as was only right, gained the day.

What stronger proof, from another side, of the intellectual need to obtain a conceptual unity in this matter selected and re-arranged according to a physical need, than the reduction of the object of Touch, Resistance, to a minimum, an Atom, colourless, odourless, tasteless, without light, and without heat, perfectly hard and perfectly elastic, unfelt, unloved, unhated, not regarded as a reality, yet used as a concept explanatory of all this full and rich world of colour, sound, taste and odour, light and heat, which we love and hate, fear and live in, with whose skies and tempers our feelings seem inwoven;—what other is it than the Ideal, set in the void and formless infinite, to represent an Idea—that of material nature reduced to concept, and spied out by thought in all her forms? If we endowed an atom with all attributes, still it would in the last resort only satisfy the intellect, conceiving even this possible, being used as an intellectual explanation of these attributes existing phenomenally. Further, it would frustrate the spirit of ideal progress, which here would be barred by a rigid absolute, devoid of mystery and wonder.

One thing is plain—that this reduction of sensory phenomena to the effects of various interactions, measured by arbitrary standards, of arbitrary minima of resistance-offering matter, is performed by the intellect (since this cannot choose its points of

view) in response to two interests: one, the instinct of physical self-preservation, here voicing its crude concept of all action as absolute spatial contact; the other, a need of intellectual unity in the world—its conformance to our thought.

Truth itself, so much worshipped by this century—what is it but an Ideal? For it is not the declaration of such and such a phase of reality, but the perfect accord of our concepts, that constitutes it; and just the nature of the universe, the nature of the subject, that their form is infinite duration, makes it an ideal. While the test of primary Reality is the one moment of consciousness, without appeal, that of all secondary Reality, consequently of Truth, is for ever eluding us. The congruity of our concepts is at every fresh moment a matter for re-examination, since the perceptual order continually offers fresh matter for fresh phases of thought. Thus it is that the first concept is the beginning of a journey *in infinitum*.

Here we might cast a short glance at the fundamental canon of this procedure, that of causation: in which, setting aside the notion of Force—a notion, it may be remarked, rather derived from the fictive power of the mind, thus a metaphor for all our treatment of reality, than from our sense of muscular exertion—setting this aside, we find two necessary notions, Necessity and Uniformity.

Necessity arises from our consciousness of the formal element, Time: every phenomenon must have an antecedent.

Uniformity—absolutely necessary for science, thus showing that this latter aims at being something more than mere registration of objective sequences—must, as a concept, be justified by the material element. Flame and water do not mingle—*Natura non facit saltum.* Yes; but who will guarantee the *non faciet?*

The only answer that one can give is that the concepts of an established sequence—flame and heat—are mutually inclusive; or, of the opposite—flame and water—mutually exclusive. But . . .

The concepts have been drawn from experience!

Or, I may be told that all phenomena are manifestations of one law, one reality—phases of atomic grouping; but the atom does not explain its particular appearances; even if it be endowed with all the qualities manifested therein, it does not explain (ah! note what we require) why this rather than that—is, in fact, only a mark of your and my need for an Absolute.

And finally, that our assumptions work well, are justified by practice; to conclude therefrom as to their truth, what is it but a further assumption as to a harmony existing between our daily practice and the nature of Truth (eternal, as we must think her)?—the last ineradicable assumption, presumption, or delusion of humanity.

We are all following the Chimæra.

§ Here we might arbitrarily end our survey of the human procedure; the moral and æsthetic processes testify more clearly as to its nature. We have seen man everywhere at work modifying—what? we cannot say—since the human procedure reaches down into perception and sensation. It would be too much presumption even to say that he works on an indifferent. Something is given, something is brute fact; but does not that very word "brute" denote its distance from us? (Is not brute fact, perhaps, another of our myths?) Fact first exists for us when our interests lead us to set a value on something; and when does this valuation first begin? None can say; it is involved in the simplest act of consciousness.

What, then, does it signify to be true to fact? To be true to one's own most lasting interests. The man who is at all costs true to brute hard fact, as he says, what else is he doing than allowing his rigid honesty to dominate all other instincts?

We have further seen—important fact—how consciousness has broken up its own unity, that it might become more fully aware of its different interests, each by each, and use them in turn as means to remodel the world. We have seen also how unsatisfactory were the results of each isolated process; and, in truth, were it not futile to remain in this divided state?

Surely, all has been just so much preparation to some greater synthesis—the complete humanisation of the Universe, when man shall have attained complete knowledge of himself—how many assumptions are here involved! (is man, then, something stable?)

§ Man's task is to spiritualise, idealise, humanise—the terms are all equivalent: is not human pride here evident?—to humanise the world; and the challenge proceeds from the Infinite.

Our negative consciousness of the infinite, the void, *inane profundum* has for emotional aspect the aspiration, or more than aspiration; *I, the Human, ought to be there*—to fill that void; or, since in the Infinite we can only live Here and Now, to feel that we stand in some satisfactory natural relation with Eternity, our most certain environment; to feel that we are indeed here and now in the place where we should be: and as reverse side of this—for all aspiration has its reverse side—the old doubt, *Ought I? am I fit?*

This existent objective universe in all its solidity—and yet this solidity is, perhaps, to a great extent our work—infinite by one at least of the cognitive forms, belongs to us—or rather we belong to it by a certain side of our nature; by another we seek to establish ourselves above it, as we, by the other and more abstract cognitive form, belong to infinity.

What is the emptiness that terrifies us in the infinite? We cannot be more swallowed up, more lost in boundless Time and

Space, than we are this very Here and Now. What we fear is that the Idea of the Infinite may be found incompatible with the Idea of the Human.

Yet we aspire.

It is the moment of thought that redresses the wavering balance.

To see ourselves *sub specie aeternitatis,* all human interests being united and the whole Human set over against the world, to take the last values and decide what it is that accords with Eternity—what it is that deserves to last; such is the reconciliation, such is our deliverance; the moment of Thought, no trimming of fear-bred tales.

We cannot always content ourselves with fragments. When we broke up the old unity and framed the first concept, we began that journey towards the last Unity of World and Human, the great Fact and Idea in one, made up of all those countless *rapports* between ourselves and Nature, which we now separately follow out. Such separate maimed human processes are only justifiable as *Vorstufen* to this synthesis.

Whatever image we make to ourselves of this Idea is called by a name soiled by all ignoble usage—the Ideal. Every human attempt at humanisation of the Universe has hitherto shaped its Ideal, and by the satisfaction which this afforded—not necessarily to the mass—has justified itself; but all have hitherto been found imperfect, sometimes perverse. To offer me the atom as a satisfactory ideal, as the trophy of a real human victory—how perverse! For what trouble does it cost to find the link between us and outer things, the interest we feel towards them, by refining on which this spectre is conjured up?

If not time and space, at least power is lacking to adumbrate that Idea. Yet we are not left without some indication of that state in which it would be given in direct intuition, where thought would be like quivering flame, inseparable from sense, emotion, and imagination. Of such perfect Life all beautiful things by their perfection—limited, 'tis true—are the fitting symbols, and the creators of Beauty in all its shapes the fitting prophets. The Eden-thought, the dream of a Golden Age, strangely offered to an unimaginative century in the shape of a philosophy which denied reason, civilisation, progress, is never absent.

To say, with that prophet and others, that our present imperfect life is a disease, were, perhaps, too glaring a substitution of Idea for Fact, an exaggeration, a *reductio ad absurdum* of the Human Procedure—the Human Fallacy, as we might cheerfully agree to call it.

No. 10.—SOCIALISM IN EDUCATION.

By P. F. Rowlands, B.A.

(*Read Tuesday, January* 11, 1898.)

No. 11.—FINANCIAL ASPECTS OF SECONDARY EDUCATION.

By P. Ansell Robin, M.A.

(Read Tuesday, January 11, 1898.)

The problems of secondary education are many and various, but they are in the main either dependent upon or closely connected with questions of finance. Both in establishing and in maintaining schools, in securing efficient masters, in fixing the scope and nature of the education supplied, in adopting methods of school management, the chief determining factor is the amount of available revenue. It is money that makes the school to go. Without an ample revenue, schools are undermanned, teachers are underpaid, the tenure of the ablest men in the profession is precarious, and the educational interests of pupils are necessarily sacrificed. Thus it is impossible to exaggerate the importance of the financial question. It is this that determines the relation of the head master or mistress to the governing body, the number, qualifications and tenure of the assistants, and to some extent the methods of school management. It is the monetary difficulty that blocks the way towards the most necessary reforms, that checks the ambitions and lowers the ideals of even the most enthusiastic and self-sacrificing schoolmasters.

Let us first take a cursory glance over the field of secondary education in Australia, and observe the different types of schools that furnish teaching higher than elementary. (1) The earliest type to emerge was that of the Denominational School, such as the King's School, the Melbourne Church of England Grammar School, Newington College, and St. Ignatius'. Long before the State took any active part in providing secondary teaching, the religious bodies, by voluntary effort, established schools of a high type, which have continued ever since to render valuable service, and in some colonies have borne the entire burden of secondary education. In some instances the State so far encouraged these efforts at the outset as to assign valuable grants of land for school purposes; but these institutions have always been self-supporting, receiving no State subsidy, except (in some few unimportant cases) the right to receive the holders of State bursaries. (2) Another type of school is exemplified in the Queensland Grammar Schools and the Sydney Grammar School. The schools have been established by local subscription, supplemented by Government aid, and assisted in their maintenance by a moderate State subsidy. Their existence is thus based upon legislative enactment,

and the Government has certain rights of inspection, which in practice are delegated to the governing body. (3) In New South Wales the State has established High Schools for boys and girls respectively, under the entire control of the Education Department. At present the number is limited; but the system admits of development with the increase of population in provincial towns. South Australia has provided a High School for girls, but has refrained from competing with the Denominational Secondary Schools for boys' education. (4) A different method of State activity is shown in the Superior Public Schools of New South Wales, and in the upper departments of State Schools in other colonies, where the primary education provided for the people is supplemented by instruction in subjects usually included among those of secondary teaching. In Victoria, State school teachers are allowed to instruct in these secondary subjects, charging a very small fee determined by the Department. (5) While the Denominational Schools represent one species of Proprietary Schools, another type has recently come into being in the Armidale Grammar School, which belongs to a company, its objects being commercial as well as educational. To this type, though with little of the commercial element, will belong the Melbourne Church of England Grammar School, if a projected scheme of reorganisation is successfully carried out. The scheme provides for 300 governors who subscribe £100 each, and the school thus endowed will be transferred to them as a legal corporation. (6) The next type, which is most numerous, but least influential, is that of private schools, whose policy and continuance depend entirely upon the pleasure or ability of individuals. Private secondary schools are relatively important only in Victoria, where for many reasons the large Denominational Schools do not command the situation, and the local worship of the Matriculation Examination has made education in the minds of most Victorians synonymous with "coaching." (7) For the sake of completeness we must not omit to mention the Technical Colleges, Schools of Mines and Art, Agricultural Colleges, and Working Men's Colleges, if we follow the British Royal Commission on Secondary Education (1895) in including Technical as a branch of Secondary instruction. With the magnificent exception of the Ormond Working Men's College in Melbourne, founded by private benefaction, these technical schools were originated by the State, and all, without exception, are dependent on State subsidy. Finally, it is necessary to remember that, apart from all these schools, a large amount of secondary instruction is given by private tutors and governesses, the proportion being, perhaps, greater in Melbourne than in any other Australian centre.

We may now inquire into the sources of revenue for secondary education. And first, how far has the principle of State aid been

extended in this direction? In earlier days grants of land were made to various religious denominations for school purposes, but now that secondary schools are plentiful, this method of State assistance is, perhaps, obsolete, at any rate in the large centres of population. Direct money grants are bestowed upon Queensland Grammar Schools, the least of them obtaining £1,000 per annum from Government, while the State safeguards its own interests by nominating about half of the governing Trustees. A more direct control is assumed by Government in the case of the State High Schools, which, however, charge fees covering a large proportion of the necessary expenditure. Each colony, again, has a system of State scholarships, whereby the ablest children in the State primary schools are enabled to continue their education in secondary schools. In Queensland these scholars naturally proceed to the Grammar Schools; in New South Wales they may enter the State High Schools, or Sydney Grammar School, which has hitherto received an annual Government grant (unfortunately diminishing). In Victoria the poverty of the Treasury has driven the Government to certain astute expedients which relieve the State of all burden, and yet secure to it the credit of providing the much-vaunted "educational ladder" to the University. By the new system the State nominally offers scholarships tenable at the large Denominational Schools, open amongst others to State scholars, the scholarships being *at the expense of the schools concerned.* The one advantage thus obtained by the schools is that these State scholars, at the end of their school course, are eligible for State bursaries, tenable at the University, such bursaries, by another stroke of official cunning, being given *at the expense of the University*, by being deducted from the annual Government subsidy.

Next, how far have secondary schools been assisted by private beneficence? Speaking generally, it may be said that the Denominational Schools have been founded by private subscription, but that in most cases a large debt still remains upon the buildings, the interest being, of course, a first charge upon ordinary revenue. One school has a debt of £25,000, another of £12,000, two more of £10,000 each; and probably a long and depressing list might easily be made if information were collected. Endowments are very rare, and comparatively trifling. Most large schools have a system of valuable scholarships, entirely due to private generosity; but while these are a valuable incentive to pupils, they in no way lighten the burden of finance, or help to increase educational efficiency. Thus the only source of ordinary school revenue is the fees of pupils, and it is obvious that all influences that tend to lower the scale of fees, or diminish the number of pupils, are so far hostile to educational efficiency. The demand for secondary education, of course, fluctuates with the general prosperity of the community, and a time of commercial depression, such as that of

the past five or six years throughout Australia, is inevitably marked by the withdrawal of pupils at an earlier age, and also by a considerable lowering of the scale of fees. This is a cause that is inherent in our present system of civilisation, and is incapable of removal by any conceivable reform. But even in prosperous times similar results are brought about by excessive competition. Private schools spring up like mushrooms, without restriction, and without any guarantee of efficiency. Any individual with sufficient enterprise or impudence may open a school; and it too often happens that pupils are attracted by low fees or blatant self-advertisement, or convenience of situation, without any inquiry into the competence or character of the teacher. But there is also the competition of Government schools, which presses heavily upon those Denominational and private institutions which are undeniably efficient. Where the Government was first in the field, as in Queensland, there is no room for complaint, and there are probably many persons who regard the Queensland system as almost an ideal one; but in New South Wales, where the churches, with great self-sacrifice, covered the ground which the State declined to occupy, the subsequent creation of Government High Schools, with a relatively low scale of fees was, and is, felt to be very unfair competition. There may possibly be room for both types of schools; but if so, the only equitable policy would be for the State to exact as high fees for secondary teaching as the self-supporting Denominational Schools are forced by their necessities to maintain.

The present financial position of secondary schools may be briefly indicated, before suggestions are offered towards reform. (1) First, the only possibility of profit, either for individuals or school-councils, is from boarding-schools; and even here there is a limit of numbers and of fees, below which even a boarding school cannot be remunerative. (2) In the second place, most efficient schools are kept efficient only by rigid economy. In almost every case the staff of assistants is maintained at the lowest possible salary consistent with efficiency. Governing bodies are at times found to adopt expedients which are unworthy of men controlling education. For instance, on the occurrence of a vacancy in the headmastership, the appointment has been sometimes bestowed upon a private schoolmaster of little reputation and mediocre attainments, for the sole reason that he already had a number of boarders whom he undertook to bring with him to the new school. In another school, a Denominational one of good standing, the council, in a time of depression, passed a resolution to dismiss the married men and substitute single men at lower salaries. This heartless plan was not actually carried out, partly through circumstances, partly through a somewhat tardy feeling of compunction; but the policy deliberately sanctioned illustrates the expedients to

which an impecunious committee feels itself at liberty to resort. Consequently, even in really good schools, assistant masters feel that there is no career open to talent, and, worse still, that through the fluctuations of finance they have no security of tenure. (3) A large proportion of schools are inefficient, because they cannot afford to engage highly-qualified assistants. There is a limit to the lowering of salaries, and as so many school authorities have set themselves to discover that limit, the natural result is that the supply of well-qualified men and women is growing less and less. It is not uncommon in private schools to find a graduate of considerable ability preparing pupils for University Public Examinations, at a salary of ten shillings a week and residence. Even in some of the largest Denominational Schools, the junior masters sometimes receive as little as £40 with residence. Is it any wonder that able men are diverted to other professions, and that those assistants who have adopted the teaching profession "for better, for worse," sometimes hear insulting innuendoes about "cheap" masters?

Is there any practicable method for securing reform? It is of no possible use to propound an ideal system of education which the founders of a new Utopia might with advantage establish. We have to reckon with existing conditions, with the inertia of schools, and with the extraordinary ignorance and apathy of the general public in all educational questions. The isolation of the various colonies in educational matters makes it necessary to convince separately those who control the respective systems, and the federation of the colonies is not in the least likely to make any alteration in this respect. The relation of Government towards secondary education needs adjusting, and probably no scheme of reform is practicable without the intelligent and discreet intervention of the State. Not that large grants of public money are required; such a contention, in the present condition of Colonial finance, would be fatal even to the discussion of the question; but the State must intervene in some way as the organiser and the patron of secondary education, so that schools may find it worth their while to reform themselves by receiving encouragement for good work, and suffering some disabilities for inefficiency. The problem here is that Governments should discharge their obligation to supervise, and yet refrain from undue interference, or any attempt to produce uniformity. These are but generalities; but State interference is so much of a bugbear to many, that its limitations must be insisted on at the outset.

I venture to propose a connected scheme which seems to contain some promise of practicability and effectiveness. The two main lines of necessary reform are—first, to ascertain which schools are efficient, and to give these official recognition and encouragement; and, secondly, as far as possible to ensure that secondary teachers

are properly qualified for their work. (I.) Suppose an Educational Council were appointed for any particular colony, such Council consisting mainly of educational experts, one half of its members nominated by the Governor-in-Council, and the rest in some way representative of the University and the body of secondary teachers. This Council would not interfere with any school that preferred to remain a law unto itself, except, perhaps, to ensure compliance with sanitary regulations, but would have some measure of jurisdiction over all schools that desired official recognition, and the advantages which that would bring. Such schools would have to satisfy the Council of their efficiency, by submitting to such inspection as the Council might prescribe or approve. The official publication of a list of such approved schools would be an immense advantage which would make recognition eagerly sought by many struggling schools. If, further, each school thus stamped with approval were given the right to receive the holders of State scholarships (at the State expense, of course), a definite, though limited, financial advantage would be added. (II.) The other important function of the Educational Council would be to create a register of qualified teachers, the qualifications to be determined by the Council. In order to make this register of practical value in raising the standard of secondary education, the Council might decree that, after a certain reasonable period of time, any school already "recognised," or desiring "recognition," must be staffed either entirely or in a certain proportion with registered teachers. On these main lines a scheme might be worked out which would revolutionise secondary education. Of course, there are many engineering difficulties; but these can be surmounted in detail after the route has been definitely mapped out. How, then, would these suggested methods work in practice? It seems reasonable to believe that the official recognition of efficient schools by a competent and impartial authority would be welcomed by the general public, that support would be more and more accorded to these schools and withdrawn from the inefficient and unworthy, that the improvement in the financial position of efficient schools would be sufficient to ensure adequate remuneration for all qualified assistants, and that the standard of education would gradually rise as teachers became more generally qualified for their profession.

No. 12—THE STATE AND SECONDARY EDUCATION.

By W. L. Atkins, B.A.

(*Read Tuesday, January* 11, 1898.)

No. 13.—SCIENTIFIC METHODS AS APPLIED TO MODERN EDUCATION.

By Miss E. A. Badham.

(*Read Tuesday, January* 11, 1898.)

No. 14.—IS THERE A SCIENCE OF EDUCATION?

By Mrs. W. L. Atkins, B.A.

(*Read Wednesday, January* 12, 1898.)

No. 15.—A NEW EDUCATIONAL EXPERIMENT; "SPECIAL SCHOOLS," IN ENGLAND AND GERMANY.

By Miss M. Hodge.

(*Read Wednesday, January* 12, 1898.)

Five years ago, inspired by Matthew Arnold with an intense admiration for the German educational system, I spent six months in visiting the schools in the Rhine district, in Hanover, Prussia, and Saxony. Although I found, for the most part, that the teachers and educational authorities were as fully convinced of the superiority of their schools over those of the other nations of Europe as Matthew Arnold appears to have been, I found myself at the close of my visit by no means confirmed in my faith. Arnold's report, however, appeared more than twenty-eight years ago, and England has, doubtless, made more rapid progress than Germany in the last quarter of a century; so that his comparison, greatly to the detriment of England, however true it may have been then, must be accepted with reservation now.

It is easy to understand why he was impressed by the German system. Education in England was in a chaotic condition; in Germany it was orderly and State regulated; but there were, and are still, more fundamental differences between the English and German systems. In Germany the appreciation of education is much more general. This may be, and probably is, due to the fact that systems of national education have been much longer established there. (Saxony had a system of national education in 1580; Prussia in 1725.) The Germans as a nation have apparently long realised

that education is the best investment they can make for their children. This is proved by a study of the School Registers, in which there is no method of marking a late attendance, and which are only occasionally opened to mark the absence of a pupil, such absence never being due to a trivial cause.

If the universal appreciation of the value of education is a striking characteristic, so is the deeper meaning given to the words. "Nicht für die Schule, sondern für das Leben," is the motto of the educational code, and the opportunities afforded by the municipal councils and the Government for self improvement and culture are not confined to the term of school-life nor limited within the school's walls.

Every small town has its theatre, which is made at once a means of literary and moral training, as Lessing pleaded a century ago that it might be. Good music is accessible to all, and admirable museums and libraries.

In the method of teaching, the Germans differ from us fundamentally. All formal instruction is based upon a sound knowledge of theory; none but trained teachers are admitted to teach in either the public or private schools. Such teachers naturally realise that their duty is rather to help on the dull and backward children than to spur on the sharp and clever ones, following the precept of Mulcaster (1531–1611.):—"Wherefore I would wish the wittier child less upon the spur, and either the longer kept from learning for fear of turning his edge as a too sharp knife, or the slenderer kept at it for fear of surfeit in one hungering to have it."

The teachers are aided in their efforts to educate rather than merely to impart information by the enlightened system of inspection which exists in Northern Germany. The Inspectors have all been teachers, and judge of the pupils and the school, not by an annual examination, "for the sake of which three hundred and sixty-four days of the year are sacrificed to one," according to an English elementary school-master, but by a series of visits and lessons given to the children throughout the year.

I must apologise for the somewhat lengthy introduction, but the "Special Schools" owe their origin and development to the great care that is taken of the individual child, and the careful watch that is kept upon his intellectual progress—not by testing the amount of information he has acquired, but by ascertaining how far he has assimilated what he has been taught, whether it be more or less than the prescribed amount being a matter of minor importance.

These special schools of Germany—Hilfs-schulen as they are called there—were founded for the reception of those children who were intellectually incapable of doing the ordinary school work, and to whom competition with normally gifted children instead of proving a spur, became a deadening and paralysing influence.

This incapacity is due—either to some defect inherent in the child at birth—a defect inherited from drunken or idiotic parents—or to some illness or neglected accident which arrested development during childhood up to the seventh year. Dr. Francis Warner has estimated that one in every thousand of the London population suffers from such an incapacity; and a recent examination of the pupils in the London School Board has shown that 1 per cent. of these children are really intellectually incapable of doing the ordinary work of the school.

Although these special schools are a distinctive feature of the German educational system, they owe their foundation to a young Swiss doctor of the name of Guggenbühl. By his observations of the Crétins, who he found could commit to memory long prayers and psalms, he conceived the idea that further training would be possible for them. He entered at once into communication with the leading Swiss teachers, some of whom were pupils of Pestalozzi, and with them he consecrated his life to the training of defective children. The first school was opened by him at Interlaken in 1839; and a school on the same plan was opened at Hubertsburg, in Saxony, that kingdom being always, since the time of Luther, to the forefront in matters educational. There are now about sixty of these schools in Germany, and their numbers are increasing through the general appreciation of their work. In Berlin, alone, there is no such school, as the Inspector of Schools in that town denies the necessity for its existence, asserting that the idiot asylums and the elementary and secondary schools supply the needs of the population.

The first institution for the education of defective children in Germany was a Government venture, and since that time the new institutions are supported either by the Government or the municipality.

The test for admission to these schools is this: If a child remain for two years in one *class in any school* without showing sufficient intellectual capacity to pass into the higher class, he is examined first by the director of the school and then by a medical man; neither examination alone is sufficient: the director is apt to mistake laziness for incapacity, and the doctor is inclined to think physical health implies mental capacity.

If the child prove to be really deficient, the parents are advised—although, of course, they cannot be compelled—to send him to a Hilfs-schule, as moral as well as intellectual deterioration will be the inevitable result of his continuing in the ordinary school, where he daily learns to realise more and more vividly the helplessness of the competition with his schoolmates, and depths of his own inferiority. At first the parents protested loudly against the assertion that their children were intellectually incapable, and

declared that their apparent inability to do the work of the school proceeded rather from laziness than from mental deficiency, preferring to charge them with moral rather than with intellectual defects. Some of the wealthier parents withdrew their children from the ordinary schools and gave them private instruction at home. Such instruction, even under a skilled master, always proved unsuccessful, as both teacher and pupil became more and more conscious of the difficulty of bridging over the great gulf that separated them intellectually one from another; and the pupil had not the stimulus of competition, nor the sympathy with fellow-workers—two powerful spurs to work in the school life. Experience has taught the parents wisdom, and in 1892, when the Town Council of Hanover decided to open one of these schools, Dr. Wehrhahn, the head inspector, received sixty-three applications for admission. From a desire to economise, and as these schools are for the most part free, or charge very low fees, each town is limited to one such institution. The schools, therefore, have to be mixed schools, as intellectual incapacity is not limited to one sex. Throughout Germany there is a holy horror of allowing boys and girls to be educated together—a horror so deep-seated that only the consideration of economy can dispel it. The girls never attain to as great proficiency as the boys, but the latter always form by far the larger proportion of the school. From motives of economy, also, one school serves for all ranks of society, and a boy from the Gymnasium works side by side with boys from the Volk-schule, reminding us forcibly of the mediæval system in the monastic schools.

Eight years are spent in the school—from 8 to 16—and during these years the moral, physical, and intellectual improvement of the scholars is very marked. Children, who come at 8 years of age, looking upon their teachers as tyrants, and their schoolmates as teasing tormenters, leave with reluctance at 16 having learned to be obedient and self-respecting. The "hope of opening out the mysterious infinite has dawned upon them with this wakening of love for working." The effectiveness of the work of these schools is best ascertained by an inspection of the children in the lowest, and a comparison with those in the highest class. In the lowest class the children are often ragged and dirty (they have not yet learned to be self-respecting), dogged, obstinate, and defiant; some of them wear a hang-dog look, due to the blame or ridicule to which they have been exposed in the public schools; but even at this stage their faces readily brighten in response to kindness or praise. The curious rhythmic fidgeting, very different from the restlessness due to the suppressed spontaneity of a healthy child, and the vacant stare observable in the lowest class, are replaced in the highest by briskness, hopefulness, energy, and self-confidence. Had these children remained in the

ordinary school they would have grown up useless burdens on society; had they been put into an idiot asylum, they would rapidly have degenerated and become idiotic.

The teaching staff in these schools is entirely composed of men, in Germany: but in England women teach throughout the school, as the infinite care and patience that are necessary are supposed to be rather feminine than masculine qualities. The number of the staff is large in proportion to the number of the pupils, the classes never numbering more than thirty, as a great deal of individual attention is necessary.

Curriculum.—For eight years the pupils do as much work as is done in the ordinary schools in two years. The hours of instruction are twenty-six and twenty-two hours weekly; but the individual lessons are much shorter and much more varied than in the ordinary schools. The length of the ordinary "Stunde" is from forty-five to fifty one minutes, but in the special schools few lessons are longer than twenty minutes.

Physical training is very carefully supervised in the big gymnasium (Turnhalle) as many of the children have never learnt to control their muscular movements. Manual training has much time devoted to it, and the children delight in carpentering and bookbinding, when they can see actual visible results of their work; indeed, so great is the children's delight in learning "*to do*" that the manual work of the afternoon is made conditional upon the conscientious performance of the mental work in the morning.

An æsthetic training is given the children by decorating the schoolroom with bright attractive pictures, although the English schools are far inferior to the German in this respect. The delight of the children in anything in the form of a picture shows how necessary such decorations are for the schoolroom. Music and singing are largely used to enliven the lessons, and the children are most enthusiastically delighted to sing loyal and patriotic songs. Luther said, "Ein schulmeister musz singen können, sonst seh ich ihn nicht an"; and although we may not consider that to be able to sing is obligatory on all teachers, it should certainly be made an essential qualification for a teacher in these schools.

Object lessons, or lessons in observation (Anschauungs-unterricht) as the Germans more correctly call them, play a large part in the school curriculum; and in the lower forms it is often pathetic to hear the children attempting to describe what they see; in fact, as Dr. Shuttleworth truly observed, the method pursued with these children may be described as a continuation of the Kindergarten. The great object of the teacher should be to keep always in close touch with the concrete. Arithmetic is the great difficulty, these children finding problems, even the simplest, quite beyond them at first, though before they leave school they can understand and work easy problems in fractions.

No history is taught except Scripture history, in which a great many lessons are given to prepare boys and girls for confirmation. The subject, however, is too remote from their experience for the children really to understand it. I witnessed one whole lesson, in which the teacher devoted much time and energy to endeavouring to clear up the confusion in his pupils' minds between the heathen and the Christian significance of the Christmas festival—between Weihnachtsmenn and Christ.

Special lessons are given on the business of life, and the teacher's desk contains a miscellaneous collection of stamps, railway tickets, and small change.

I have already touched upon the moral effect of these schools. It is at once touching and delightful to see the glow of pride as the children show, with eagerness, the results of their work ; and it is vastly important to the community at large to know that out of thirty-five children turned out after eight years' course at the Brunswick school, twenty-nine are at present earning their livelihood.

"Was Kostet mehr die Idioten erziehen oder vernaschlässigen ?" asks the head of one of these institutions.

The School Board for London has now instituted, since 1893, twenty-five special schools in London. These do not seem to be attended with quite as much success as the German Schools, but it is as yet too soon to judge ; and even after many years of such work the teachers must be prepared for discouragement

When I gave evidence before the Committee of the London School Board, the Chief Inspector of Schools, Mr. Sharpe, was anxious to discover in what respect our schools differed from the German Schools. I think the difference lies in this : The Germans realise, "it is not important what we learn, but what we become through education" ; so they lay far less stress on the attainment of knowledge and avoid the danger of cram.

I would urge, then, the adoption of these schools, not only for the happiness of the children—

> "The mind is its own place, and, in itself,
> Can make a Heaven of Hell, a Hell of Heaven."

but for the good of the community, for it does not need a Herbart to remind us of the close connection between mental deficiency and moral depravity.

Let us try and find for these poor children "the right path of a virtuous and noble education, laborious indeed at the first ascent, but else so smooth and green, so full of goodly prospects and melodious sounds on every side that the harp of Orpheus was not more charming."

Let us build schools that we may demolish prisons ; for it is from this class the intellectually defective—that our criminal class is largely recruited. Launched into the world with no sense

of moral responsibility, and utterly deficient in self-respect, they rejoice in using the poor powers with which they are endowed by Nature to endeavour to cheat and outwit a world from which they have experienced nothing but harshness and contempt.

The mocking laugh, the coarse jest with which the streets of our large towns too often resound—unlovely and mirthless sounds—are all signs of the vacant mind. It is for us, as educators, to find food capable of assimilation by such minds—to open out to them the wonderful storehouse of knowledge, to substitute for the pleasures of the sense the higher pleasures of the intellect; to render unhappy, helpless burdens upon society cheerful and useful members of it.

[Since writing this paper in 1897, the writer has heard of two institutions for the training of mentally deficient children, in the Southern Hemisphere—one at Kew, Victoria, and one at Adelaide.]

No. 16.—TEACHING *VERSUS* EDUCATION.

By Miss H. Newcomb.

(*Read Wednesday, January* 12, 1898.)

No. 17.—THE RATIONALE OF MIRACULOUS CURES IN MODERN DAYS.

By Dr. S. T. Knaggs.

(*Read Wednesday, January* 12, 1898.)

No. 18.—EVOLUTION AND SOCIOLOGY.

By Dr. T. F. Macdonald.

(*Read Wednesday, January* 12, 1898.)

No. 19.—STATE TECHNICAL EDUCATION BY A SYSTEM OF PAYMENTS BY RESULTS.

By Professor D. C. SELMAN.

(*Read Thursday, January* 13, 1898.)

No. 20.—FRIEDRICH NIETZSCHE.

By C. J. BRENNAN, M.A.

(*Read Thursday, January* 13, 1898.)

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Exchanges and Presentations

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The Association's Report for 1898, Vol. VII, has been forwarded to the following Societies and Institutions; should the publication not have arrived, the Institution concerned is requested to communicate with the Permanent Hon. Secretary, the University, Sydney, in order that inquiry may be made.

* *Exchanges of Publications have been received, since Vol. VI (Brisbane,* 1895 *Session) was issued, from the Societies and Institutions distinguished by an asterisk.*

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5	Buenos Aires ...	National Library.
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8	Prague	*Königlich Böhmische Gesellschaft der Wissenschaften.
9	Trieste	Società Adriatica di Scienze Naturali.
10	Vienna	*Anthropologische Gesellschaft.
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12	,, ...	K. K. Central-Anstalt für Meteorologie und Erdmagnetismus.
13	,, ...	K. K. Geographische Gesellschaft.
14	,, ...	K. K. Geologische Reichsanstalt.
15	,, ...	*K. K. Zoologisch-Botanische Gesellschaft.

BELGIUM.

16	Brussels	Académie Royale des Sciences, des Lettres et des Beaux Arts.
17	,, ...	Observatoire Royale de Bruxelles.
18	Liége	Société Géologique de Belgique.
19	,, ...	Société Royale des Sciences de Liège.
20	Luxembourg ...	Institut Royale Grand-Ducal de Luxembourg.
21	Mons	Société des Sciences, des Arts et des Lettres du Hainaut

BRAZIL.

22	Rio de Janeiro ...	*Observatoire Impérial de Rio de Janeiro.
23	,, ...	National Library.

CHILI.

24 Santiago ... ... Sociedad Cientifica Alemana.

DENMARK.

25 Copenhagen ... Société Royale des Antiquaires du Nord

FRANCE.

26 Bordeaux ... Académie Nationale des Sciences, Belles-Lettres et Arts.
27 Caen ... ... Académie Nationale des Sciences, Arts et Belles-Lettres.
28 Dijon ... ... *Académie des Sciences, Arts et Belles-Lettres.
29 Havre ... ... *Société Géologique de Normandie.
30 Lille ... ... *Société Géologique du Nord.
31 Marseilles ... *Faculté des Sciences de Marseille.
32 Montpellier ... Académie des Sciences et Lettres.
33 Nantes ... ... *Société des Sciences Naturelles de l'Ouest de la France.
34 Paris ... ... Académie des Sciences de l'Institut de France.
35 ,, ... Bibliothèque de l'Université à la Sorbonne.
36 ,, ... Comptoir Géologique de Paris.
37 ,, ... Ecole Nationale des Mines.
38 ,, ... *Muséum d'Histoire Naturelle.
39 ,, ... Ministère de l'Instruction Publique, des Beaux Arts, et des Cultes.
40 ,, ... *Revue Critique de Paléozoologie. Address to Monsieur G. Ramond, Assistant de Géologie au Muséum d'Histoire Naturelle, 61 Rue de Buffon.
41 ,, ... *Société d' Encouragement pour l' Industrie Nationale.
42 ,, ... Société Française de Minéralogie.
43 ,, ... Société Française de Physique.
44 ,, ... Société Géologique de France.
45 ,, ... Société Philotechnique.
46 Toulouse... ... Académie des Sciences, Inscriptions et Belles-Lettres.

NEW CALEDONIA.

47 Noumea ... ... Government Library.

GERMANY.

48 Berlin ... ... Deutsche Chemische Gesellschaft.
49 ,, ... Gesellschaft für Erdkunde.
50 ,, ... Königlich Preussische Akademie der Wissenschaften.
51 Bremen ... ... *Naturwissenschaftlicher Verein zu Bremen.
52 Bonn ... ... *Naturhistorischer Verein der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück.
53 Brunswick ... Verein für Naturwissenschaft zu Braunschweig.
54 Carlsruhe ... *Naturwissenschaftlicher Verein zu Carlsruhe.
55 Cassell ... ... Verein für Naturkunde.
56 Chemnitz ... Naturwissenschaftliche Gesellschaft zu Chemnitz.
57 Dresden ... ... Königliches Mineralogisch Geologische und Praehistorisches Museum.
58 ,, ... Statistische Bureau des Ministeriums des Innern zu Dresden.
59 ,, ... Verein für Erdkunde zu Dresden.
60 Elberfeld ... Naturwissenschaftlicher Verein in Elberfeld.
61 Frankfurt a/m ... Senckenbergische Naturforschende Gesellschaft.
62 Freiburg (Saxony) Königlich Sächsische Berg-Akademie.
63 Freiburg (Baden) *Naturforschende Gesellschaft.
64 Giessen ... ... *Oberhessische Gesellschaft für Natur-und-Heilkunde.

65	Gorlitz ...	... *Naturforschende Gesellschaft in Görlitz.
66	Gotha ...	... Dr. Petermann's Geographische Mettheilungen.
67	Göttingen	... *Königliche Gesellschaft der Wissenschaften in Göttingen.
68	Halle, A. S.	... *Kaiserliche Leopoldina Carolina Akademie der Deutschen Naturforscher.
69	Hamburg	... *Naturhistorisches Museum.
70	,,	.. *Verein für Naturwissenschaftliche Unter haltung in Hamburg.
71	Hannover	... Naturhistorische Gesellshaft.
72	Heidelberg	... Naturhistorisch-Medicinischer Verein zu Heidelberg.
73	Jena ...	... Medicinisch-Naturwissenschaftliche Gesellschaft.
74	Königsberg	... *Königliche Physikalisch-Okonomische Gesellschaft.
75	Leipzig ...	... Königliche Sächsische Gesellschaft der Wissenschaften.
76	,, ...	... Verein für Erdkunde.
77	Marburg...	... *Gesellschaft zur Beförderung der gesammten Naturwissenschaften in Marburg.
78	Munich ...	... Königlich Bayerische Akademie der Wissenschaften in München.
79	Stuttgart	... Verein für Vaterländische Naturkunde in Württemberg.
80	Wurtemberg	... *Verein für Vaterlandische Naturkunde.
81	Würzburg	... *Physikalisch-Medicinische Gesellschaft.

Great Britain and the Colonies.

82	Birmingham	... *Birmingham and Midland Institute.
83	,,	... Birmingham Natural History and Philosophical Society.
84	,,	... Central Free Library.
85	,,	... Saltley Training College.
86	Bristol ...	... Bristol Naturalists' Society.
87	Camborne	... Mining Association and Institute of Cornwall.
88	Cambridge	... Philosophical Society.
89	,,	... Public Free Library.
90	,,	... Union Society.
91	,,	... University Library.
92	Kew ...	... Royal Gardens
93	Leeds ...	... *Leeds Philosophical and Literary Society.
94	,, ...	... *Yorkshire College.
95	Liverpool	... Literary and Philosophical Society.
96	London ...	... Agent-General (two copies).
97	,, ...	... Anthropological Institute of Great Britain and Ireland.
98	,, ...	... British Museum (Library), Bloomsbury.
99	,, ...	... British Museum (Natural History), South Kennsington.
100	,, ...	... Chemical Society.
101	,, ...	... Colonial Office, Downing-street.
102	,, ...	... Folk Lore Society.
103	,, ...	... Geological Society.
104	,, ...	... Guild Hall Library.
105	,, ...	... *Institute of Chemistry of Great Britain and Ireland.
106	,, ...	... Institution of Civil Engineers.
107	,, ...	... Iron and Steel Institute.
108	,, ...	... Library, South Kensington Museum.
109	,, ...	... Linnean Society.
110	,, ...	... Lords Commissioners of the Admiralty.
111	,, ...	... Museum of Practical Geology.
112	,, ...	... Patent Office Library.
113	,, ...	... *Physical Society of London.
114	,, ...	... Royal Astronomical Society.
115	,, ...	... *Royal Colonial Institute.
116	,, ...	... Royal Geographical Society.

117	London ...	... *Royal Historical Society.
118	,, ...	... *Royal Institution of Great Britain.
119	,, ...	... Royal School of Mines and College of Science.
120	,, ...	... Royal Society.
121	,, ...	... *Society of Arts.
122	,, ...	... University of London.
123	,, ...	... Victoria Institute (or Philosophical Society of Great Britain).
124	,, ...	... *War Office. (Intelligence Division.)
125	Manchester	... *Literary and Philosophical Society.
126	,, ...	... Manchester Geological Society.
127	,, ...	... Owens College.
128	Mirfield ...	... Yorkshire Geological and Polytechnic Society.
129	Newcastle-upon-Tyne.	Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne.
130	,,	... *North of England Institute of Mining and Mechanical Engineers.
131	,,	... Society of Chemical Industry.
132	Oxford ...	... Bodleian Library.
133	,, ...	... Radcliffe Library.
134	Penzance	... *Royal Geological Society of Cornwall.
135	Plymouth	... Plymouth Institution and Devon and Cornwall Natural History Society.
136	Windsor...	... The Queen's Library.
137	York ...	... Yorkshire Philosophical Society.

CAPE OF GOOD HOPE.

138	Cape Town	... *Department of Geology.
139	,,	... *South African Philosophical Society.

CEYLON.

140	Colombo...	... Royal Asiatic Society (Ceylon Branch).

DOMINION OF CANADA.

141	Halifax (Nova Scotia).	*Nova Scotian Institute of Science.
142	Hamilton (Ont.)..	Hamilton Association.
143	Montreal	... *Natural History Society of Montreal.
144	,,	... Royal Society of Canada.
145	Ottawa ...	... Geological and Natural History Survey of Canada.
146	Quebec ...	... Literary and Historical Society.
147	Toronto ...	... *Canadian Institute.
148	,, ...	... University.
149	Winnipeg	... Manitoba Historical and Scientific Society.

INDIA.

150	Aligarh ...	.. Anglo-Oriental College.
151	,, ...	... Elphinstone College.
152	Bombay ...	... Royal Asiatic Society (Bombay Branch).
153	Calcutta ...	... Asiatic Society of Bengal.
154	,, ...	... Geological Survey of India.
155	,, ...	... Indian Museum.
156	,, ...	... Museum.
157	Madras ...	... Central Museum.

IRELAND.

158 Dublin ... ... Royal Dublin Society.
159 ,, ... Royal Geological Society of Ireland.
160 ,, ... Royal Irish Academy.
161 ,, ... Trinity College.

JAMAICA.

162 Kingston .. *Institute of Jamaica.

MALTA.

163 Malta ... ... Public Library.

MAURITIUS.

164 Port Louis .. *Royal Society of Arts and Sciences.

NEW BRUNSWICK.

165 St. John... .. *Natural History Society of New Brunswick.

NEW SOUTH WALES.

166 Sydney ... ... Australian Economic Association.
167 ,, ... *Australian Museum.
168 ,, ... Department of Mines and Agriculture.
169 ,, ... Department of Public Instruction.
170 ,, ... Engineering Association of New South Wales.
171 ,, ... *Government Statistician.
172 ,, ... Linnean Society of New South Wales.
173 ,, ... *Mining Department.
174 ,, ... N. S. Wales Government Railways Institute.
175 ,, ... Observatory.
176 ,, ... Parliamentary Library.
177 ,, ... Public Library.
178 ,, ... *Royal Geographical Society of Australasia (New South Wales Branch).
179 ,, ... School of Arts.
180 ,, ... Technological Museum.
181 ,, ... University.
182 ,, ... *Zoological Society.

NEW ZEALAND.

183 Auckland ... Auckland Institute.
184 Christchurch ... Philosophical Institute of Canterbury.
185 ,, ... Public Library.
186 Coromandel ... School of Mines.
187 Dunedin ... ... Otago Institute.
188 Wellington ... *New Zealand Institute.
189 ,, ... *Polynesian Society.
190 ,, ... *Registrar-General.

QUEENSLAND.

191 Brisbane... ... *Geological Survey of Queensland.
192 ,, ... Parliamentary Library.
193 ,, ... Queensland Museum.
194 ,, ... *Royal Geographical Society of Australasia (Queensland Branch).
195 ,, ... *Royal Society of Queensland.

SCOTLAND.

196 Aberdeen ... University.
197 Dumfries ... *Dumfries and Galloway Natural History and Antiquarian Society.
198 Edinburgh ... Edinburgh Geological Society.
199 ,, ... *Royal Observatory.
200 ,, ... Royal Physical Society.
201 ,, ... Royal Society.
202 ,, ... University.
203 Glasgow ... Geological Society of Glasgow.
204 ,, ... Philosophical Society of Glasgow.
205 ,, ... University.
206 St. Andrews ... University.

SOUTH AMERICA.

207 Demerara (British Guiana). ... Royal Agricultural and Commercial Society.

SOUTH AUSTRALIA.

208 Adelaide ... *Geological Survey of South Australia.
209 ,, ... Government Botanist.
210 ,, ... Observatory.
211 ,, ... Public Library, Museum, and Art Gallery of South Australia.
212 ,, ... *Royal Geographical Society of Australasia (South Australian Branch).
213 ,, .. Royal Society of South Australia.
214 ,, ... University.
215 ,, ... Zoological Society.

STRAITS SETTLEMENTS.

216 Singapore ... Royal Asiatic Society (Straits Branch).

TASMANIA.

217 Hobart ... Parliamentary Library.
218 ,, ... *Royal Society of Tasmania.
219 Launceston ... Geological Survey of Tasmania.

VICTORIA.

220 Ballarat ... School of Mines and Industries.
221 Melbourne ... *Australasian Institute of Mining Engineers.
222 ,, ... Field Naturalists' Club of Victoria.
223 ,, ... Government Botanist.
224 ,, .. Government Statist.
225 ,, ... Medical School Library, University.
226 ,, ... *Mining Department.
227 ,, ... Observatory.
228 ,, ... Parliamentary Library.
229 ,, ... Public Library.
230 ,, ... Registrar-General.
231 ,, ... *Royal Geographical Society of Australasia (Victorian Branch).
232 ,, ... Royal Society of Victoria.
233 ,, ... University.
234 ,, ... Victorian Institute of Engineers.
235 ,, ... Victorian Institute of Surveyors.
236 ,, ... Working Men's College.
237 ,, ... Zoological Society.

WESTERN AUSTRALIA.

238 Perth ... ... Museum.
239 ,, ... Parliamentary Library.
240 ,, ... Victoria Public Library.

GREECE.

241 Athens ... ... National Observatory.
242 ,, ... University.

HAYTI.

243 Port-au-Prince ... Société de Sciences et de Géographie.

ITALY.

244 Bologna ... ... *R. Accademia delle Scienze dell'Istituto.
245 ,, ... Università di Bologna.
246 Catania ... ... *Accademia Gioenia di Scienze Naturali.
247 Florence ... . Reale Museo Zoologia.
248 Milan .. ... Reale Istituto Lombardo di Scienze Lettere ed Arti.
249 Modena ... ... Regia Accademia di Scienze, Lettere ed Arti.
250 Naples ... ... Società Reale di Napoli (Accademia delle Scienze Fisiche e Matematiche).
251 Palermo ... ... Reale Accademia Palermitana di Scienze Lettere ed Arti.
252 Pisa ... ... *Società Toscana di Scienze Naturali.
253 Rome ... ... Accademia Pontificia de Nuovi Lincei.
254 ,, ... R. Accademia dei Lincei.
255 ,, ... *R. Comitate Geologico d' Italia.
256 Siena ... ... R. Accademia dei Fisiocritici in Siena.
257 Turin ... ... Reale Accademia della Scienze.
258 Venice ... ... Reale Istituto Veneto di Scienze, Lettere ed Arti.

JAPAN.

259 Tokyo ... ... *Asiatic Society of Japan (formerly in Yokohama).
260 ,, ... *Imperial University.
261 ,, ... Seismological Society of Japan.

JAVA.

262 Batavia ... ... *K. Natuurkundige Vereeniging in Nederl-Indië.

MEXICO.

263 Aguascalientes ... *El Instructor.
264 Mexico ... ... *Instituto Geólógico de Mexico.
265 ,, ... *Sociedàd Cientifica "Antonio Alzate."

NETHERLANDS.

266 Amsterdam .. Académie Royale des Sciences.
267 Haarlem... ... Bibliothèque de Musée Teyler.
268 ,, ... *Colonial Museum.
269 ,, ... Société Hollandaise des Sciences.
270 Leyden ... .. University.

NORWAY.

271 Christiania ... *Köngelige Norske Fredericks Universitet.

PORTUGAL.

272	Coimbra	Universidade.
273	Lisbon	Academia Royale das Sciencias.

RUSSIA.

274	Helsingfors ...	Société des Sciences de Finlande.
275	Kieff	Société des Naturalistes.
276	Cracow	*Academie des Sciences.
277	Moscow	Société Impériale des Amis des Sciences Naturelles d· Anthropologie et d' Ethnographie à Moscow (Section d' Anthropologie).
278	St. Petersburg ...	Académie Impériale des Sciences.
279	,, ...	*Comité Géologique—Institut des Mines.

SERVIA.

280	Belgrade... ...	Academie Royale de Serbie.

SOUTH AFRICA.

281	Johannesburg ...	Geological Society of South Africa.
282	,, ...	*Chemical and Metallurgical Society of S. A.

SOUTH AMERICA.

283	Caracas	University Library.
284	Monte Video ...	National Library.

SPAIN.

285	Barcelona ...	*Real Academia de Ciencias.
286	Madrid	Universidad.

SWEDEN.

287	Stockholm ...	*Kongliga Svenska Vetenskaps-Akademien.
288	Upsala	Kongliga Vetenskaps Societeten.
289	,, ...	*Universite Royale d' Upsala.

SWITZERLAND.

290	Berne	Allg. Schweizerische Gesellschaft.
291	Geneva	*Société Helvétique des Sciences Naturelles.
292	Lausanne ...	Société Vaudoise des Sciences Naturelles.
293	Neuchatel ...	Société des Sciences Naturelles de Neuchatel.
294	Zurich	*Naturforschende Gesellschaft.

UNITED STATES OF AMERICA.

295	Albany	*New York State Library, Albany.
296	Baltimore ...	*Johns Hopkins University.
297	Berkeley... ...	University of California.
298	Boston	American Academy of Arts and Sciences.
299	,, ...	City Public Library.
300	,, ...	State Library of Massachusetts.
301	Brookville (Ind.)	Indiana Academy of Sciences.
302	Buffalo (Ind.) ...	Buffalo Society of Natural Sciences.
303	Cambridge (Mass.)	Harvard University Library.

304	Chicago	Academy of Sciences.
305	Concord	New Hampshire State Library.
306	Denver	Colorado Scientific Society.
307	Hoboken (N.J.)...	Steven's Institute of Technology.
308	Indianopolis ...	*Indiana Academy of Sciences.
309	Lawrence ...	*Kansas University.
310	Madison (Wis.) ..	Wisconsin Academy of Sciences, Arts, and Letters.
311	Meriden (Conn.)..	Meriden Scientific Society.
312	Minneapolis ...	*Minnesota Academy of Natural Sciences.
313	New Haven (Conn.)	American Journal of Science.
314	,, ...	*Connecticut Academy of Arts and Sciences.
315	,, ..	Yale University.
316	New York ...	American Chemical Society.
317	,, ...	American Institute of Mining Engineers.
318	,, ...	American Museum of Natural History.
319	,, ...	Columbia University Library.
320	,, ...	*New York Academy of Sciences.
321	,, ...	School of Mines, Columbia College.
322	Palo Alto ...	Leland Stanford Junr. University of California.
323	Philadelphia ...	Academy of Natural Science.
324	,, ...	American Philosophical Society.
325	,, ...	Franklin Institute.
326	Rochester (N.Y.)	*Rochester Academy of Science.
327	Salem (Mass.) ...	*American Association for Advancement of Science.
328	,, ...	Essex Institute.
329	St. Louis ...	Academy of Science.
330	San Francisco ...	*California Academy of Sciences.
331	,, ..	California State Mining Bureau.
332	Stanford	University of California.
333	Washington ...	Bureau of Education (Department of the Interior).
334	,, ..	*Bureau of American Ethnology.
335	,, ...	Department of Agriculture, Library.
336	,, ...	Library (Navy Department).
337	,, ...	*Microscopical Publishing Co.
338	,, ...	National Academy of Sciences.
339	,, ...	*Philosophical Society.
340	,, ...	Secretary (Department of the Interior).
341	,, ...	*Smithsonian Institution.
342	,, ..	*U.S. Geological Survey.
343	,, ...	*U.S. National Museum (Department of the Interior, Smithsonian Institution).

ADDITIONAL (TOO LATE FOR THE ABOVE LIST).

France (Paris) ...	*Société de Géographie.
,, ,, ...	*Société de Spéléologie.
Germany (Bonn)	*Niederrheinische Gesellschaft für Natur-und-Heilkunde.
,, (Brunn)	*Naturforschender Verein.
U.S. America (Chicago)	*John Crerar Library.

Number of Publications sent to		Great Britain and Ireland	71
,,	,,	India and the Colonies	87
,,	,,	U.S. of America	54
,,	,,	Europe...	117
,,	,,	Asia, Africa, South America, &c. ...	19
		Total...	348

Additions to the Library

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Australasian Association for the Advancement of Science.

[Donations from 1 July, 1895, to 30 June, 1898.]

City or Country.	Donations.	Donors.
Adelaide.........	Geological Survey of South Australia	The Department.
	Report of the Northern Territory Explorations, 1895.	
	Record of the Mines of South Australia—The Balhannah Mine ; The Wadnaminga, 1898.	
	Royal Geographical Society of South Australia	The Society.
	Journal of the Elder Scientific Exploring Expedition, 1891–2, with accompanying Maps.	
	Journal of the Horn Scientific Exploring Expedition, 1894, with accompanying Maps.	
Aguascalientes, Mexico.	El Instructor..	Dr. Jesus Diaz de Léon.
	Vol. XIII. Nos. 10–12, 1897.	
	Vol. XIV. Nos. 1–3, 5–10, 12, 1897.	
	Vol. XV. Nos. 1–4, 1898.	
Albany, N.Y., U.S.A.	New York State Library.............................	The Museum.
	Bulletins of the N.Y. State Museum. Vol. III, Nos. 12–15.	
	Annual Report of the State Botanist, 1895.	
Baltimore	Johns Hopkins University	The University.
	University Circulars. Vol. XIII, No. 109.	
	,, ,, Vol. XIV, Nos. 119–20.	
	,, ,, Vol. XV, Nos. 121–2.	
	,, ,, Vol. XVI, Nos. 128-131.	
	,, ,, Vol. XVII, Nos. 132–3, 135, 136, 1898.	
Barcelona	Real Academia de Ciencias y Artes	The Academy.
	Boletins. Vol. 1, Nos. 12, 18, 19, 1894–8.	
Batavia	Koninklijke Natuurkundige Vereeniging in Nederlandsch–Indië.	The Society.
	Boekwerken, 1893, 1895, 1896, 1897.	
	Alphabetisch Register of Deel. 1–XXX, 1871. XXXI to L, 1891.	
	Alphabetisch Naamregister, 1872.	
	Catalogue Supplementaire, 1883–93.	

Additions to the Library—*continued.*

City or Country.	Donations.	Donors.
Batavia	Koninklijke Natuurkundige Veeriniging in Nederlandsch-Indië. Natuurkundig Tijdschrift. Vols. XXXI–XXXIII, 1869–73. Vols. XXXV–XXXIX, 1875–1880. Vols. XLI–XLIX, 1881–1891. Vols. L–LVII, 1891–1897.	The Society.
Birmingham ...	Birmingham and Midland Institute .... Programmes for Session 1896–99.	The Institute.
Bologna	Reale Accademia delle Scienze .... Rendiconto delle Sessioni, 1893–4, 1894–5, 1895–6, 1896–7.	The Academy.
Bonn	Naturhist. Verein der Preussischen Rheinlande. Verhandlungen. Series 6, Vol. XI, No. 2. Vol. XII, Nos. 1–2, 1894. Vol. XII, Nos. 1–2, 1895. Vol. XIII, Nos. 1–2, 1896. Vol. XIV, Nos. 1–2, 1897.	The Society.
	Niederrheinische Gesellschaft fur Natur-und Heilkunde zu Bonn. Sitzungsberichte. Parts 1–2, 1895. Parts 1–2, 1896. Part 2, 1897.	The Society.
Bremen	Naturwissenschaftlicher Verein zu Bremen ... Abhandlungen. Vol. XIII, Part 2, 1895. Vol. XIII, Part 3, 1896. Vol. XIV, Part 1, 1895. Part 3, 1898. Beiträge zur Nordwestdeutschen Volks-und Landeskunde. Vol. XV, Parts 1, 2, 1895–7.	The Society.
Brisbane.........	Royal Geographical Society of Australasia...... Proceedings and Transactions. Vol. X, 1894–5. Vol XI, 1895–6. Vol. XII, 1896–7. Geography in Australasia (Anniversary Address), by the President, J. P. Thomson, F.R.G.S., 1896. An Historical Review, by Alex. Muir, J.P., 1896.	The Society.
	Royal Society of Queensland .... Proceedings. Vol. XI, Parts 1 and 2. Vol. XII, 1897. Vol. XIII, 1897.	The Society.
	Department of Mines .... Geol. Survey. Bulletin, No. 7, 1897.	The Department.
	Queensland Government .... Supplements to Gazettes, 1896–8.	The Government Printer.
Brunn............	Naturforschender Verein .... Bericht der Meteorn. Commission, XIV, 1894 Verhandlungen, XXXIV, 1895.	The Society.
Capetown	South African Philosophical Society............... Transactions. Vol. VIII, Part 2, 1892–5. Vol. VII, Part 2, 1896. Vol. IX, Part 1, 1895–6. Vol. IX, Part 2, 1896–7. Vol. X, Part 1, 1897.	The Society.

Additions to the Library—*continued.*

City or Country.	Donations.	Donors.
Capetown	Department of Geology	The Department.
	Bibliography of South African Geology. Parts 1–2, 1897.	
Catania	Accademia Gioenia di Scienze Naturali in Catania.	The Society.
	Atti. Vol. IX, Part IV, No. 73, 1896.	
	Bullettinos. 44–49, 1896–7.	
	Bullettinos delle sedute. Fascicolos LI and LII, 1898.	
Chicago	John Crerar Library	The Librarian.
	Third Annual Report, for the year 1897.	
Christiania	Fauna Norvegiæ. Vol. I, 1896	G. O. Sars.
	Norronaskaller, 1896	G. A. Guldberg.
Cracow	Academie des Sciences..................................	The Academy.
	Bulletins International, Comptes Rendus, March to July, 1898.	
Dijon	L'Academie de Dijon	The Secretary.
	Memoires. Vol. V, No, 4, 1895–6.	
Dumfries	Dumfriesshire and Galloway Natural History and Antiquarian Society.	The Society.
	Transactions and Journal of Proceedings, 1895–6.	
Florence.........	Anomalie ottiche dell'Analcima, 1897	Giovanni D'Achiardi.
Freiburg-in-Baden.	Naturforschende Gesellschaft	The Society.
	Berichte. Vol. IX, Parts 1–3, 1894–5.	
Geneva	Société Helvétique des Sciences Naturelles ...	The Society.
	Actes de la réunion à Schaffhouse. Vol. 77, 1894.	
	Actes de la réunion à Zermatt. Vol 78, 1895.	
	Comptes Rendus des Travaux, Zermatt. Parts 1–2, 1895.	
Giessen	Oberhessische Gesellshaft	The Society.
	Bericht fur Natur-und Heilkunde. Part 31.	
Görlitz...........	Naturforschende Gesellschaft...................... ..	The Society.
	Abhandlungen. Band 22, 1898.	
Göttingen	Königliche Gesellschaft der Wissenschaften ...	The Society.
	Nachrichten Mathematisch-physikalische Klasse, 1895, Nos. 1–4. 1896, Nos. 1–4. 1897, Nos. 1–3. 1898, Nos. 1–3.	
	Nachrichten Geschäftliche Mittheilungen, 1895, Nos. 1–2. 1896, Nos. 1–2. 1897, Nos. 1–2. 1898, No. 1.	
Halifax, Nova Scotia.	Nova-Scotian Institute of Science..................	The Institute.
	Proceedings and Transactions. Vol. I, Second series, Parts 1, 3, 4. Vol. II, Parts 1–2.	
	Vol. IX, Part III. New series, 1896–7.	
Halle	Kais.-Leop.-Carolina Akad. der Deutschen Naturforscher.	The Academy.
	Acta. Vols. LXIII–LXVIII–LXIX.	

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City or Country.	Donations.	Donors.
Hamburg	Naturhistorisches Museum.........................	The Museum.
	Mittheilungen. Vol. XI, 1893.	
	,, Vol. XIII, 1895.	
	Verein für Naturwissenschaftliche Unterhaltung zu Hamburg.	The Society.
	Verhandlungen. Band IX, 1894–5.	
	Mittheilungen. XIV, Jahrgang, 1896. Part 2.	
Hobart	The Royal Society of Tasmania	The Society.
	Papers and Proceedings, 1894–5 and 1896.	
Indianopolis, U.S.A.	Indiana Academy of Sciences	The Academy.
	Proceedings, 1896.	
Karlsruhe	Naturwissenschaftlicher Verein	The Society.
	Verhandlungen, 1888–95.	
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